Architect's Stainless Steel Library

DESIGN MANUAL

THE INTERNATIONAL NICKEL COMPANY, INC.

PREPARED IN COOPERATION WITH COMMITTEE OF STAINLESS STEEL PRODUCERS, AMERICAN IRON AND STEEL INSTITUTE

Architect's Stainless Steel Library

Volume 4

THE INTERNATIONAL NICKEL COMPANY

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Foreword

Successful architectural design depends upon a thorough knowledge of the materials at the command of the designer. This volume provides the designer with information on stainless steel to assure better execution and solution of design problems. The development of stainless steel, its salient properties and the basic forms in which it is available are explained herein. Also, the possibilities of fabrication and the knowledge developed through previous design experience with the material are included.

An additional section for eventual incorporation in this Volume IV, to be entitled "Details," is scheduled for future preparation and will cover design details for a wide range of building components and products. *Upon completion, this section will be forwarded as a supplement to this volume.*

As an introduction to this part of Volume 4, several noteworthy examples are presented which illustrate effective uses of stainless steel. Architectural applications of stainless steel have multiplied during the past decade, and all the indicators point to an extension of this trend. We hope this book will contribute to the freedom with which the architect may participate in that trend.

Introduction

EXAMPLES OF EFFECTIVE DESIGN

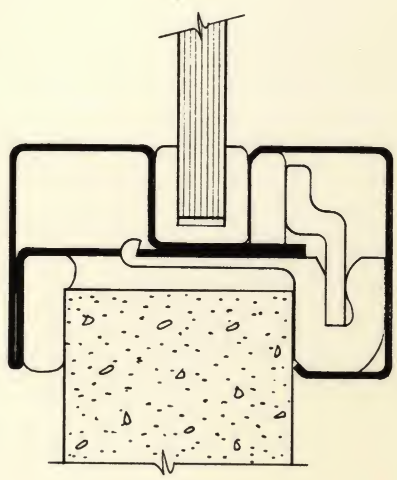
To achieve the most effective use of stainless steel, architects should design specifically for stainless. Too often, metals have been approached as equals, and alternate stainless steel bids have been estimated from drawings which detail a metal of different properties. Stainless costs more per pound than some other metals, but when the job is carefully detailed for stainless steel, a stainless bid is competitive.

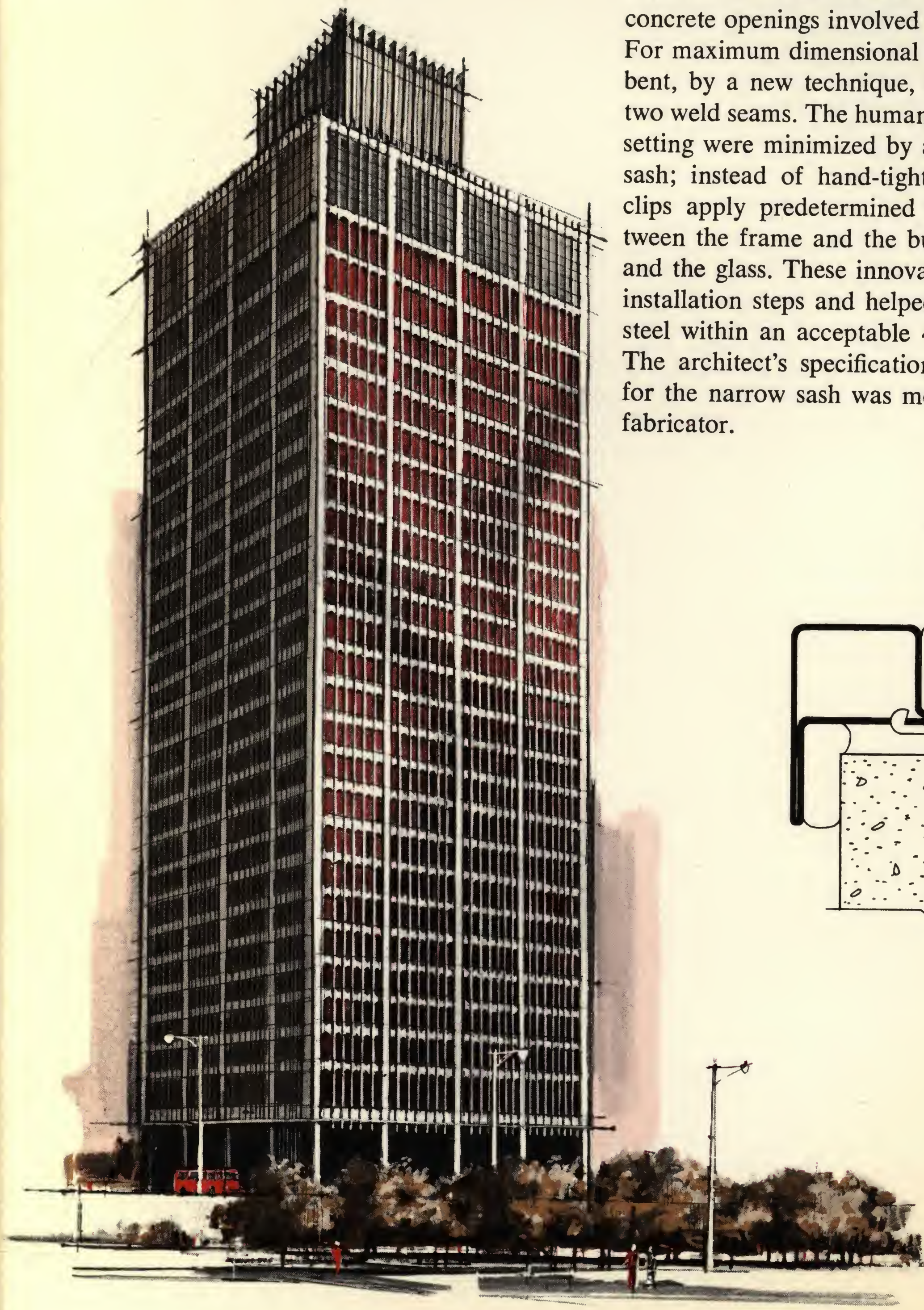
The following examples are presented for their architectural interest and serve to illustrate imaginative and economical use of stainless steel.

MICHIGAN CONSOLIDATED GAS COMPANY BUILDING
DETROIT, MICHIGAN

Architects: Minoru Yamasaki
Smith, Hinchman and Grylls

The exterior wall design is notable for its lanced hexagonal windows in stainless steel. Setting the windows in preformed concrete openings involved interesting problems and solutions. For maximum dimensional accuracy, the roll-formed sash was bent, by a new technique, to form two halves requiring only two weld seams. The human error factors in glazing and frame-setting were minimized by an ingenious clip system inside the sash; instead of hand-tightened retaining screws, aluminum clips apply predetermined pressure to neoprene gaskets between the frame and the building lug and between the frame and the glass. These innovations also reduced fabrication and installation steps and helped bring the initial cost of stainless steel within an acceptable 4 percent of an all-aluminum bid. The architect's specification of a bright stainless steel finish for the narrow sash was met with a proprietary finish by the fabricator.



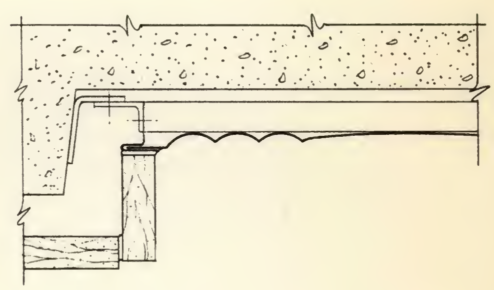


BANK OF CALIFORNIA BUILDING
TIDEWATER OIL BUILDING
KIRKEBY CENTER BUILDING
LOS ANGELES, CALIFORNIA

Architect: Claude Beelman

The architect considered stainless steel, marble and glass the appropriate materials, functionally and esthetically, for these buildings. His devotion to good design in a series of outstanding buildings has contributed much to the economical use of stainless. The Beelman series demonstrates the results of designing in stainless steel for ease of maintenance.

On these buildings, vertically striated panels of stainless steel alternate with columns of polished marble. The windows are framed with stainless, and the narrow sills present minimum surfaces for trapping dirt.



In 1966, an inspection team of the American Society for Testing and Materials focused its maintenance report on the Bank of California building. It was considered the best maintained structure seen on the team's tour of seven Gulf Coast and Pacific Coast cities. The building superintendent credited the combination of stainless steel and careful design for maintenance costs that are below average for the area.

Beelman's approach to Kirkeby Center, his last structure, represents his accumulated experience with the materials. Henry Blaesing, manager of the building, recently told an architectural symposium audience that in the preliminary stages, "Our architect pointed out that the difference between the lowest cost exterior treatment and the best materials would amount to only 1 percent of the total construction cost. This was seemingly a small amount to pay for such premium materials. . . . Later I discovered from our architect that when we took bids . . . our stainless steel portion was bid at the same price as the aluminum bid. In this case the theoretical premium did not exist."

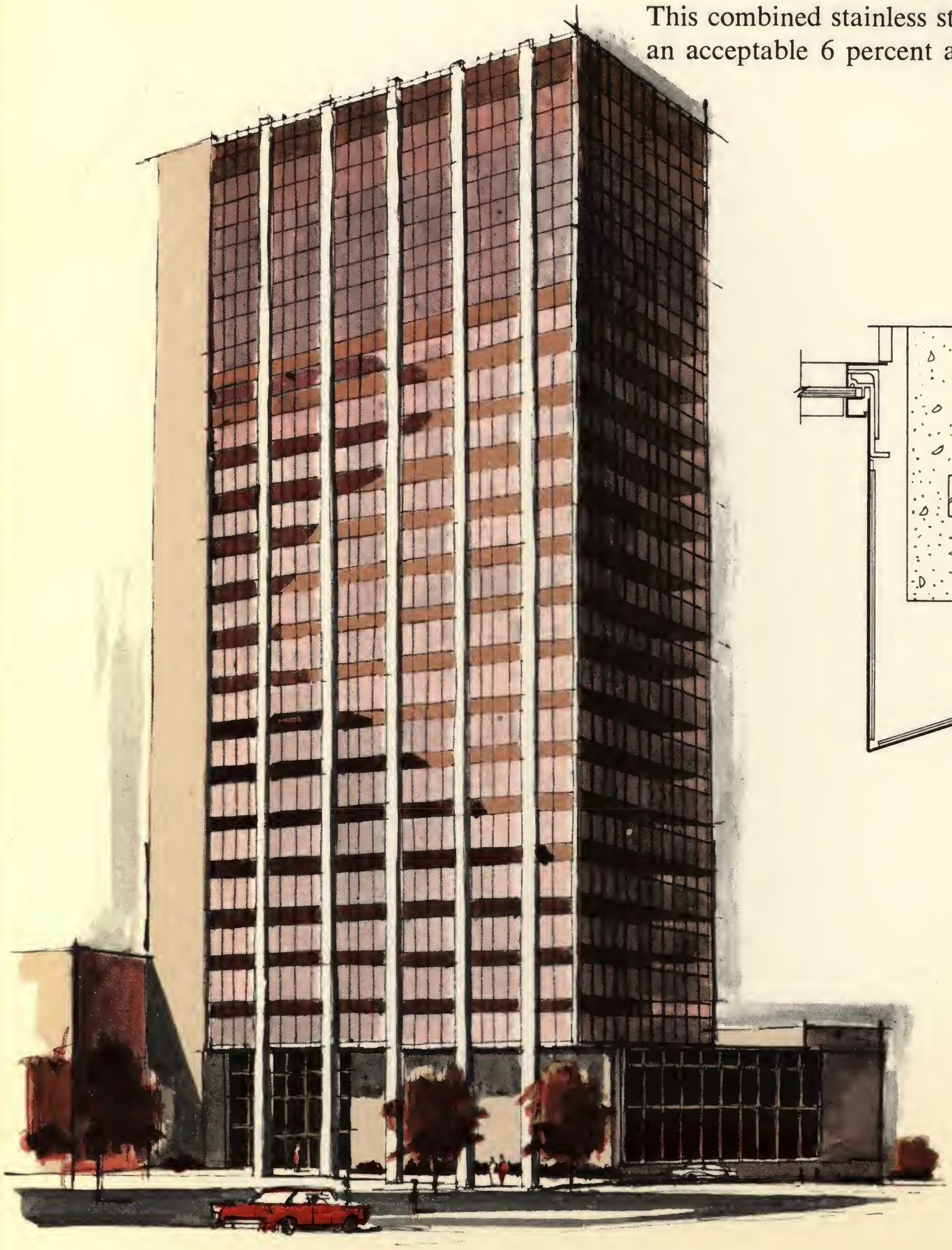
UNITED ENGINEERING CENTER BUILDING

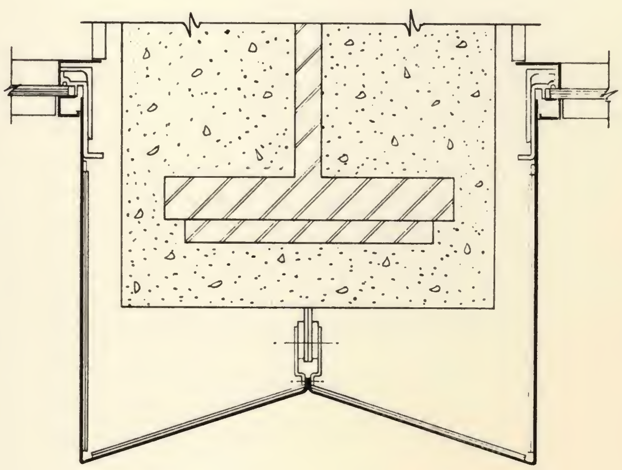
NEW YORK, NEW YORK

Architect: Shreve, Lamb and Harmon

The United Engineering Building is another building that enjoys the benefits of stainless steel at relatively low cost. The exterior column covers and the curtain wall framing utilize simple shapes in Type 302 stainless sheet.

The wide column covers, designed for strong vertical emphasis, imposed a test of stainless steel flatness. Matte finish 14 gauge stainless in V-profile, with 16 gauge bent-Z stainless stiffeners, met the requirements. AISI #4 finish was used on the curtain wall framing members and mullions to accent the wall panels. This combined stainless steel and aluminum design was bid at an acceptable 6 percent above an all aluminum design.





IBM BUILDING

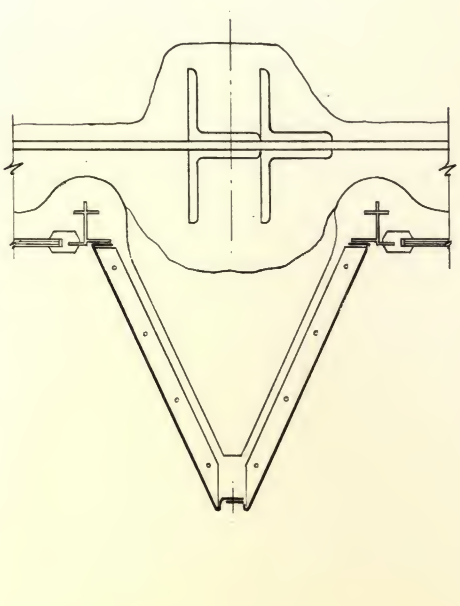
GATEWAY 5, PITTSBURGH, PENNSYLVANIA

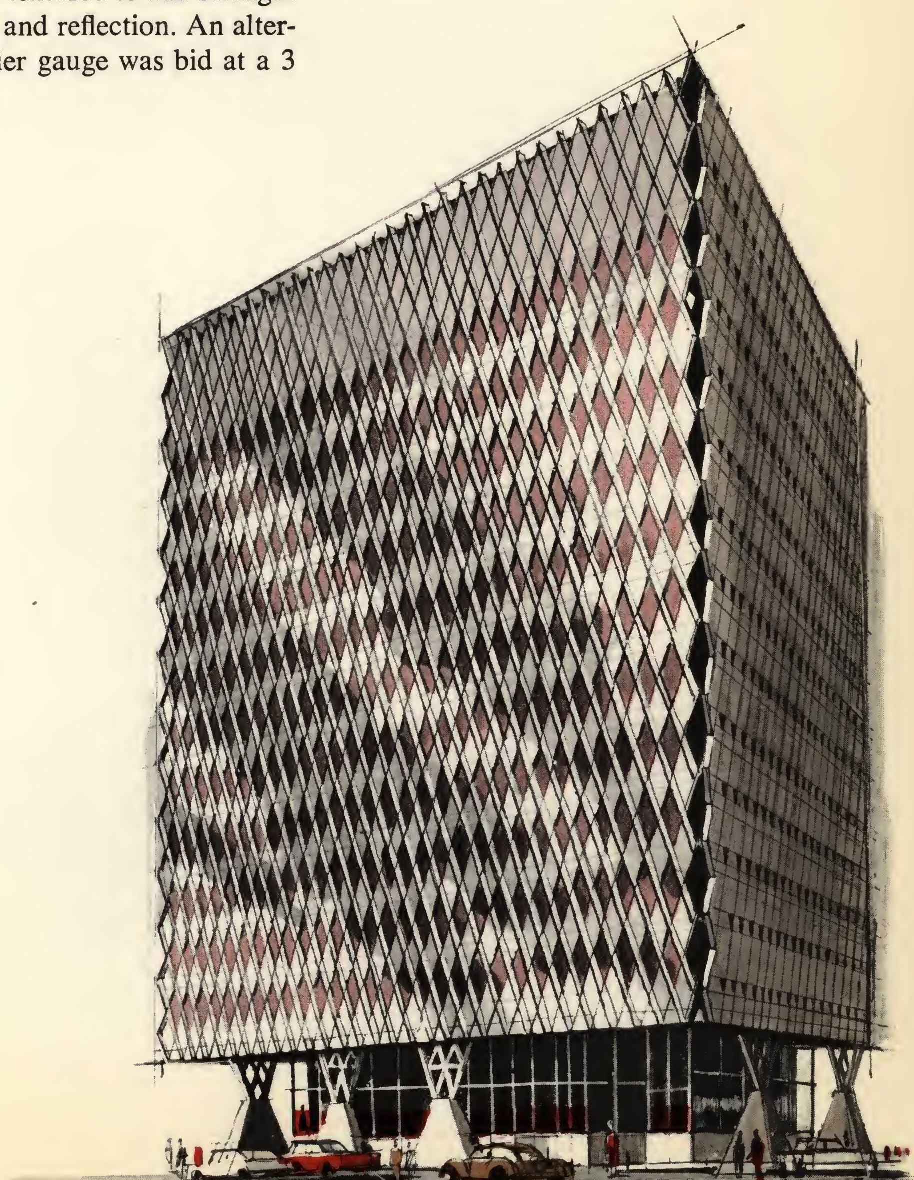
Architect: Curtis & Davis

The truss wall of this building has attracted attention as an example of integration between structural function and architectural expression.

Diamond-shaped stainless shadow boxes create a patterned facade emphasizing the structure. Fabricated from brake formed sections, each unit is joined at the outer edge to form a continuous, flexible skin. Stainless steel triangular inserts above and below each window contribute to rigidity. Each unit is attached to the building by welded angles above and below the window.

The design takes advantage of the strength, flexibility and low thermal expansion of stainless steel. Type 302, 22 gauge stainless sheet was used. The sheet was textured to add strength and to help eliminate visual distortion and reflection. An alternate aluminum design requiring heavier gauge was bid at a 3 percent premium.





HARRIS TRUST SAVINGS BANK BUILDING

CHICAGO, ILLINOIS

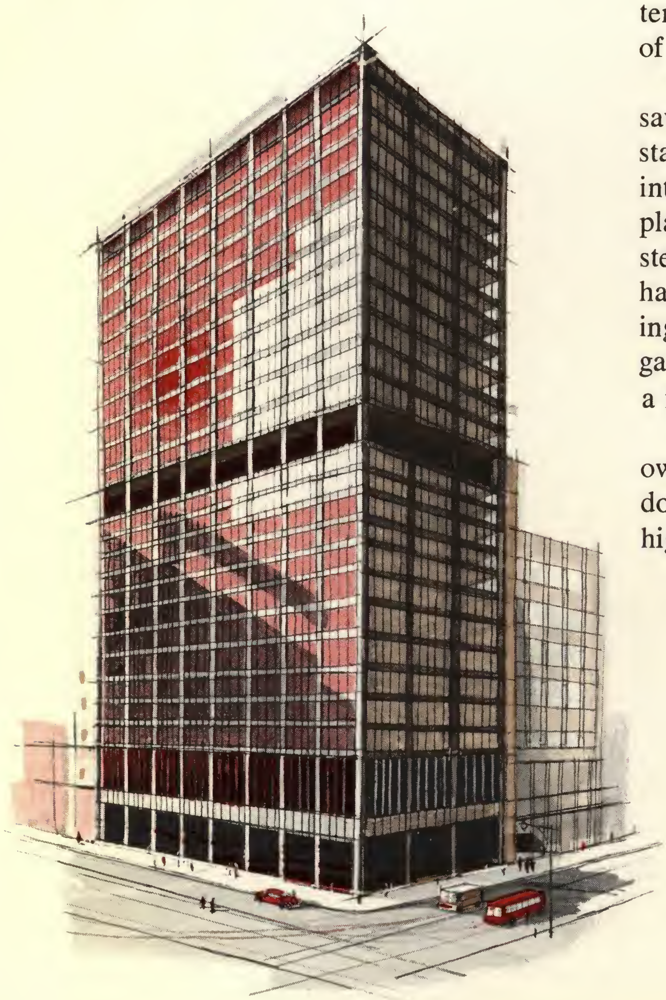
Architect: Skidmore, Owings and Merrill

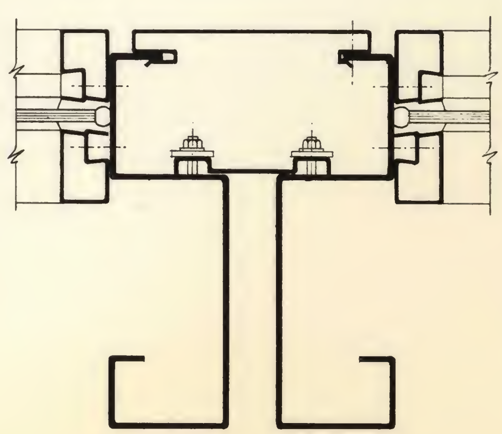
Designs may be used not only in initial cost comparisons but also as the basis of actual projected maintenance cost calculations. In combination, these estimates can provide a long-term economic determination. The 23-story addition to the Harris Trust Building is an example. Bank management and their architects arrived at the final specifications through a careful process.

At the outset, three separate curtain wall detail drawings were made for aluminum, bronze and stainless steel. Based on these drawings, the bid for stainless was 16 percent more than the bid for aluminum, and 32 percent less than bronze. Advance bidding of maintenance contractors, however, established an advantage of $9,000 a year for stainless steel. Recommendations by maintenance consultants and a maintenance study of the University of Illinois led to the selection of stainless steel.

An unusual mullion design contributed to both erection cost savings and good maintenance characteristics. The 12 gauge stainless mullions were designed in vertical halves, which were integrated with the stainless steel spandrels at the fabricator's plant to form story-high panels. On installation, a stainless steel strip was used to close the one inch gap between mullion halves. The spandrels consist of a 16 gauge stainless steel facing backed with two inches of honeycomb insulation and a 20 gauge steel backing sheet. All stainless steel is Type 302 with a fabricator's #4 finish on the visually exposed side only.

Performance verifies the maintenance cost projection. The owner reports that routine cleaning included in monthly window washing keeps the building appearance up to the required high standard.





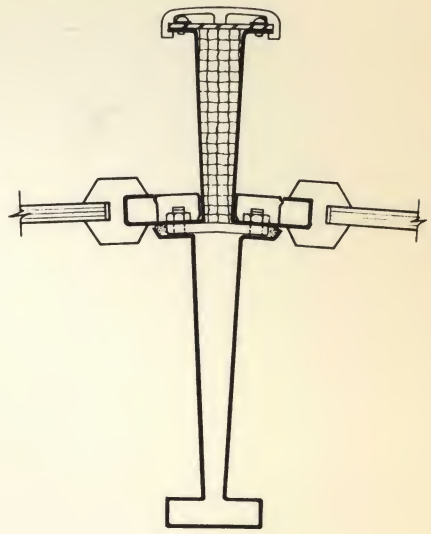
TORONTO CITY HALL BUILDING

TORONTO, ONTARIO, CANADA

Architects: John B. Parkin Associates
Viljo Revell

One of the most spectacularly original structures of recent years, the Toronto City Hall complex, features stainless steel curtain walls on the facing concave surfaces of its two large office towers. The architects preferred stainless steel for its esthetic and maintenance characteristics, but estimates based on preliminary rough outlines placed stainless steel costs at more than twice that of aluminum. Before specifications were finalized, however, a design was developed for a stainless steel mullion and window framing system which was bid at an acceptable 4½ percent above aluminum.

The cost reduction was accomplished through a design in 16 gauge stainless steel. It is an ingeniously simplified system with thermal movement minimized by the low coefficient of expansion of stainless and further accommodated by the resiliency of the stainless mullion. In this way, considerable caulking is eliminated.



INTERIOR APPLICATIONS

Exterior treatments receive more notice as architecture, but as aspects of stainless steel design, entrance and interior components are equally important. For banks, public buildings, terminals, the public areas of office buildings and other such locations, stainless steel often is a logical interior material, regardless of the facade treatment.

Typically, such buildings and areas are designed for a combination of high traffic conditions, a high standard of appearance and long life expectancy. Maintenance is an important economic factor. Metal components and various metal covers and panels are specified for easy cleanability and long durability. Preference of stainless steel stems from its outstanding resistance to abuse without additional surface treatment and its compatibility with a variety of color schemes. In many maximum abuse applications, it may be worth considering that while either stainless steel or another material will serve for the life of the building, only stainless will always remain as attractive as when it was installed.

Besides elements normally detailed by the architect, a variety of standard stainless steel products are manufactured. These include elevator and escalator components, control panels, light and service fixtures, hardware, furniture and many other items.

BUFFALO and ERIE COUNTY PUBLIC LIBRARY BUILDING

BUFFALO, NEW YORK

Architects: Kideney, Smith & Fitzgerald
Paul Harbach and Elon B. Clark, Jr.

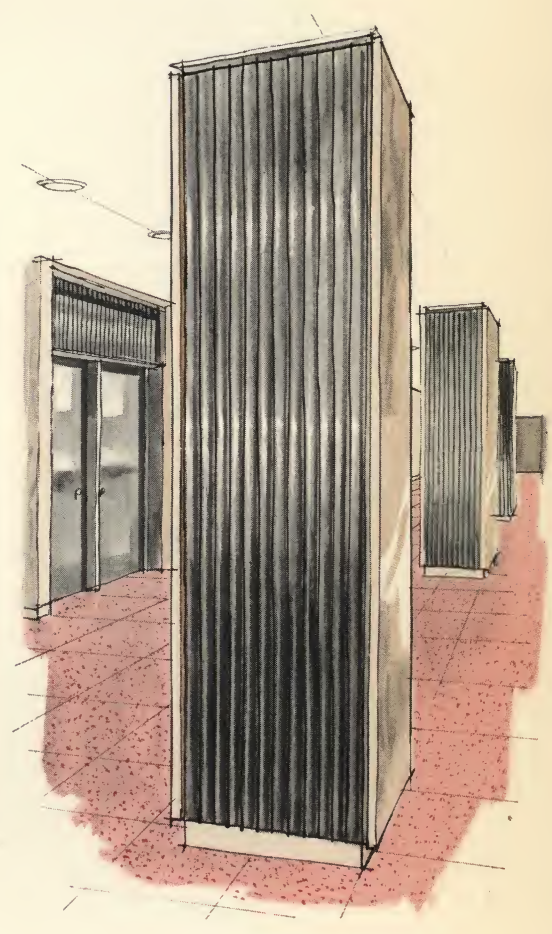
This building is an excellent example of stainless steel design for interior components and entrances. Throughout the public areas of this building, marble and stainless steel form a large portion of the surfaces that are seen and touched. Use of Type 302 stainless in the fabricator's satin finish on all stainless steel components contributes to visual continuity.

The wide stainless steel column covers are formed in a fluted pattern that provides visual interest as well as a stiffening effect enabling the use of lightweight (22 gauge) stainless. The stainless panels are slightly recessed between marble panels.

The fluted pattern is repeated in stainless door transoms. A number of flush stainless doors are featured which utilize an unusually wide, hollow core design, with 16 gauge stainless steel providing the surface over steel structural members. The door openings, also, are framed in stainless steel.

The entrance doors of the building and the entrance framing combine stainless steel and glass, and a stainless framed glass wall or partition also separates an interior lounge area from the lobby and reading areas. In the lounge, stainless steel is used for benches and smoking stands, with wood paneling on the walls providing contrast.

Extensive runs of convector covers under the windows are stainless sheet over steel framing. Railings and hand rails throughout the building and at the entrance are stainless steel bar stock.



BACKGROUND

Stainless Steel

the Aristocrat of Metals

Stainless steels, a product of this modern age, stand alone among metals for their rare combination of strength, eye appeal, resistance to corrosion and heat, and ease of cleaning. In the brief years since their commercial utility was first recognized, advances in a broad spectrum of industries have depended on the use and adaptation of stainless steels. In automobiles, in appliances, and in everyday household use, stainless steels are an essential part of our lives. The aero-space age looks to stainless steels and their unique properties for the solution to countless problems. Trends in design, application, and fabrication are enhancing stainless steels' architectural potential. In all respects, stainless steels are truly 20th century metals.

HISTORY

Both chromium and nickel are important in the production of stainless steels; therefore, the development of each is discussed. Chromium's discovery was made in 1797 by Vauquelin, one of the famous chemists of the day. By 1821, Berthier had produced a true alloy of iron with one or two per cent chromium. In 1895, Goldschmidt in Germany broke the bond between carbon and chromium by developing the thermite process. In this process, aluminum, in powder form, and chromium oxide were mixed and placed in a magnesium oxide lined crucible generating heat of 6000° Fahrenheit—and pure chromium!

Nickel in alloy form has an ancient history. Prehistoric man used meteoric iron containing 5 to 15 per cent nickel for his implements and jewelry. Early coins of about 235 B.C. from Asia Minor were found to contain nickel in almost the same proportions as today's United States nickel, and the early Chinese long used an alloy of nickel, copper and zinc called "paktong," which is much like the nickel silver in current use.

Nickel itself was not isolated until 1751, when Cronstedt prepared an impure metallic nickel from arsenical ore that the Saxon miners called "kufpernickel." Cronstedt decided to apply this name to his new metal. In 1775 Bergman confirmed Cronstedt's results, and the name "nickel" was accepted. Until recently, high purity nickel was best produced by the Mond process, not perfected until 1895.

A consulting metallurgist and noted historian of the age of steel, Dr. Carl A. Zapffe, has seen fit to spread the credit for the discovery of stainless steel among a number of people, each of whom made a separate but necessary contribution. In rough chronological sequence, the primary metallurgical char-

acteristics of the stainless steels were uncovered from 1902 to 1910 by Dumas, Guillet and Portevin of France, and Geison of England. These independent studies built in sequence upon the ground work laid by each.

The "stainlessness" of stainless steel is a discovery attributed to Monnartz of Germany in 1911. Brearley of England, long regarded as the formal discoverer of stainless steel, has been given a position in history by Zapffe as the man responsible for the discovery of the "commercial utility" of stainless steel. Strauss and Maurer, in Germany, made the most important discoveries by developing the 18-8, chrome nickel series. Caleb Hornbostel, in "Materials for Architecture," gives additional credit to the research conducted by Becket in the United States.

PRODUCTION

The remarkable properties of stainless steel depend upon a minimum chromium content of 11.5 per cent and a maximum carbon content of .15 per cent. The electric furnace, in which the majority of stainless steel is produced, provides the close control of temperature and atmosphere, in the refining reactions necessary to produce steel of a desired chemical composition. The first electric steel furnace was built in 1904 in the United States, and it soon replaced the crucible process for making high grade alloy steels and tool steels.

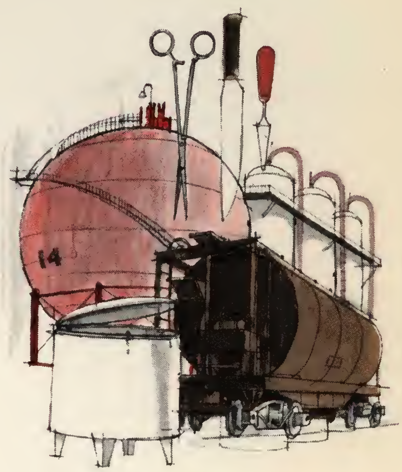
The electric furnace is completely lined with refractory brick. Two large electrodes (a 40″ diameter is the maximum at present) extend down into the furnace, and the temperature is controlled by raising and lowering these electrodes. The electric current arcs to the slag, creating heat between electrode and top of slag, and then passes through the slag, which offers resistance and thus creates more heat; the current then passes in sequence through the metal, back up through the slag, and arcs to the other electrode. Because the metal is hotter at the electrodes, a constant motion or stirring of the molten metal occurs.

Selected scrap containing only those elements which are required in the finished product (in general, chromium and nickel) comprises the bulk of the furnace charge. Lime, silica, crushed coke, aluminum, silicon, flourspar and iron ore are used for forming the slag and controlling the composition of the molten metal.

During the process, analyses of the molten metal are made frequently. Additions, such as various oxidizing or reducing slags, may be made, alloying elements may be added and the carbon and sulfur content is precisely controlled. When the required chemical composition is reached, the contents of the furnace are poured into ladles and from there into ingots. Primary rolling mills convert the ingots to slabs and subsequently to products such as plate, sheet and bars. All of these proce-

dures are slower and more precise than those used for regular steel mill operations.

FIRST COMMERCIAL USES



Original commercial applications of stainless steel were in the cutlery trade. The ability to withstand oxidation at high temperatures resulted in such applications as steam turbine blades in 1914. Stainless steels' corrosion resistance feature became known to the chemical and drug industries as well as to other industrial operations where severe corrosion conditions exist and contamination of product must be avoided. The hygienic and antiseptic requirements of hospitals and food handling operations are invariably served by stainless.

Soon afterwards, the strength and ductility of stainless resulted in its use in railroad car components with resultant structural inmprovements and weight saving economies. This was followed by the development of stainless tank cars and trailer bodies for commercial freight transportation.

Today, stainless has no peer in many industries as the most logical and economical choice of material.

PLACE IN ARCHITECTURE

Architectural uses of stainless steel are wide and far ranging, and additions are constantly being made based upon new design concepts. Among the uses, for example, are exterior and interior wall components, doors, windows, trim, grilles, louvers, screens, counter tops, railings, roofing, flashing, gutters, signs, and letters. The first outstanding use of stainless in buildings was the Chrysler Building in New York, built in 1929, designed by architect William Van Allen. Although the walls are of masonry, the ground floor entrance is stainless and the entire tower is sheathed with stainless steel, as are the Gargoyles which project from two of the setbacks. The structure serves as a reminder that fantasy as well as efficiency has a place in architecture, and that stainless steel can be used to express both equally well. The following year stainless was used by architects Shreve, Lamb & Harmon on the Empire State Building as a major design element of the exterior wall in the vertical metal trim between stone piers. Flashing of stainless steel was also included. In recent years the use of stainless has become more common as illustrated earlier in this volume.

PROPERTIES

Properties

INTRODUCTION

This section is a guide to the selection of stainless steel types suitable for specific applications. Table 2 lists properties of standard stainless steel types commonly used for most architectural applications, as classified and listed by the American Iron and Steel Institute (AISI).

The corrosion resistance information is given to assist the architect in understanding the significance and usage of alloy selection.

CLASSIFICATION AND TYPES

Stainless steel is a family of corrosion and heat resisting steels containing a minimum of about 11.5 percent chromium. The corrosion resistance is improved by increasing the chromium content and both corrosion resistance and fabricating characteristics are further improved through modification with nickel. Other elements, such as molybdenum, manganese, columbium, aluminum, silicon, sulphur, and titanium, are also added for certain specific applications.

CLASSIFICATIONS

The primary classification of stainless steels is based on their internal metal structure which in turn is based on alloy content. Stainless steels thereby fall into one of three groups according to their structure, namely: austenitic, martensitic, and ferritic, and are further classified by alloy types according to a numerical system developed by the American Iron and Steel Institute (AISI).

AUSTENITIC stainless steels (AISI 300 and 200 series) contain both chromium and nickel, or chromium, nickel and manganese, and are non-magnetic. They are not heat-treatable, but can be strengthened and hardened considerably by cold working. They are readily amenable to most fabrication techniques and have excellent weldability.

MARTENSITIC stainless steels (400 series) contain chromium and little or no nickel and are magnetic. They are hardenable by heat treatment and can be cold worked with difficulty.

FERRITIC stainless steels (400 series) are without nickel and are magnetic. They are not hardenable by heat treatment, but can be slightly hardened by cold working. They are readily fabricated but do not retain as much ductility as the austenitic grades after cold work.

AISI TYPES

*Architectural Alloys

Cr-Ni-Mn	Cr-Ni		Cr	Cr
Austenitic	*Austenitic*		*Martensitic*	*Ferritic*
*201	*301	309S	*410	*430
*202	*302	310	403	430F
	302B	310S	414	430F Se
	303	314	431	442
	303Se	*316	416	405
	*304	316L	416Se	446
	304L	317	420	
	*305	321	440A	
	308	347	440B	
	309	348	440C	

TABLE 1

ATMOSPHERIC CORROSION RESISTANCE

The corrosion resistance of stainless steels provides architectural products that are good for the life of any building, will require minimum maintenance and will protect associated building components from staining by corrosion products.

Among other things an architect must consider in choosing a metal for a building component are:

1. Ability to retain desired appearance
2. Compatibility with other materials
3. Ability to retain structural strength
4. Cost of maintenance

It will be found that stainless steels will meet the test of these considerations. Stainless steels have an excellent ability to retain their characteristic metallic luster through years of accumulated industrial soot and grime. Furthermore, when cleaning is performed, stainless will be restored to its original appearance.

There are many compositions of stainless steel designed for particular purposes in industry and architecture. Those listed in table 2 to be dealt with here are of principal interest to architects.

OXYGEN IN THE ATMOSPHERE

The resistance of stainless steels to corrosion resides in their ability to take advantage of the oxygen in the atmosphere in forming an invisible oxide film which prevents further attack.

Suggestions on design in the "Design and Detail" section will provide ways in which maximum access to the beneficial effects of atmospheric oxygen may be obtained, e.g., by minimizing opportunities for accumulation of dirt and polluted liquids in crevices and pockets.

USE OF TYPE 302 AND TYPE 304

Types 302 and 304 stainless steels have a record of highly satisfactory performance in the industrialized cities in North America, e.g., New York, Chicago, Philadelphia, Pittsburgh, Toronto, etc. The corrosion resistance of these basic types of stainless steel is well illustrated by the Chrysler Building in New York City that has withstood the effects of weather for a period of more than 35 years.

The range of severity of exposure conditions that can be withstood satisfactorily is broadened by the effects of other alloying elements. For example, molybdenum is especially helpful in the presence of unusually large amounts of chlorides that may be present in atmospheres very close to the

ocean or near chemical plants processing halogen compounds. Molybdenum also provides extra resistance to sulfurous compounds from the burning of high-sulfur fuels in localities where the relative humidity is frequently very high.

USE OF TYPE 316

For these reasons, the grade that contains molybdenum (Type 316) may be preferred in seaside installation especially where there are frequent fogs and heavy dews with extended periods between heavy rains. It may also be preferred in damp sulfurous atmospheres like those in London and in close proximity to chemical plants processing halogen compounds.

Even under the most adverse circumstances the nickel stainless steels will not be corroded enough to suffer significant structural damage. The principal concern is the extent to which the appearance may be marred by superficial staining and the frequency with which surfaces will require cleaning to preserve the desired appearance.

COMPATIBILITY WITH OTHER MATERIALS

Stainless steels get along well with other materials used along with them in architectural applications. Although stainless steels are the most noble of all architectural metals they are less aggressive than other corrosion resisting metals, e.g., copper and bronzes, in accelerating galvanically the corrosion of such less noble metals as steel or aluminum. This accounts for the preference for nickel stainless steel fasteners for joining aluminum.

NON-STAINING CHARACTERISTICS

The stainless steels have the advantage over copper and high copper containing alloys of not releasing copper compounds in corrosion products that can cause accelerated attack on aluminum or zinc surfaces with which they may come into contact by drainage. This feature is also important in avoiding unsightly staining of marble or other masonry located below the metal in a structure.

PROTECTION AND CLEANING

Protection of stainless steel surfaces during fabrication and erection and recommendations for cleaning are dealt with in the "Fabrication" section.

CORROSION IN ACTION

The phenomenon of corrosion of metals has been the subject of considerable scientific investigation and a further discussion of it here is considered inappropriate. Interested readers are referred to INCO's publication, "Corrosion in Action". The text is essentially the narrative of the motion

picture of the same name. The film itself was produced by the International Nickel Company as an aid to the understanding of some of the electrochemical processes that result in corrosion. The publication and other reference material are available upon request.

REPORT FROM ASTM*

A task force of the American Society for Testing and Materials has completed an appraisal of the condition of architectural stainless steel installations in Seattle, San Francisco, Los Angeles, Santa Monica, Houston, Galveston, and Dallas. This is the eighth inspection performed by a task group since 1939.

The purpose of this long term project is to evaluate the use of stainless steel in architectural applications such as window frames and doors, railings, canopies, column and coping covers, louvers, and various types of trim. Stainless steels, presumably Types 302 and 304, were used in most of the installations.

CONCLUSIONS AND RECOMMENDATIONS

1. The buildings inspected demonstrated that stainless steel used in architectural applications can result in attractive structures. These are easy to maintain and are expected to have an indefinitely long life.
2. It is recognized that stainless steels, like other materials of construction, require some maintenance to preserve an attractive appearance. The amount of maintenance required will be determined by the environment and the criterion of appearance established by the owner of the building.
3. Design should be a major consideration in the application of stainless steel for architectural use. This is particularly true in areas such as San Francisco and Galveston, where contamination from sea salts will cause rusting. Flat, horizontal surfaces should be avoided. Recessed and sheltered areas, crevices and exposed laps, where contamination can accumulate and which are difficult to clean, are potential areas of trouble and should be avoided. Often the effectiveness of flooding the surface with clean fresh water as a supplement to rain water is overlooked.
4. The stainless steel should be thoroughly cleaned when the building is completed. Sticky or oily films and construction debris should be removed.
5. The use of transparent, air-dried organic films is not recommended.
6. Stainless steel performs best when boldly exposed to the weather.

Abstracted from a summary published in* **Materials Research & Standards, *September 1965. The full report is published in the 1965 volume of* **ASTM Proceedings,** *under the title, "Report on 1964 Inspection of Stainless Steel in Architectural Applications."*

REPRESENTATIVE PROPERTIES

ALLOYS COMMONLY USED FOR MOST ARCHITECTURAL APPLICATIONS

TYPE	DESCRIPTION	CHEMICAL COMPOSITION					
		CHROMIUM	NICKEL	CARBON	MANGANESE	SILICON	OTHER ELEMENTS
201	An austenitic chromium-nickel-manganese stainless steel with virtually the same properties as 301, but having still higher yield and tensile strengths.	16.0 to 18.0	3.5 to 5.5	0.15 Max.	5.5 to 7.5	1.00 Max.	N 0.25 Max.
202	An austenitic chromium-nickel-manganese steel with much the same properties as 302, but having higher yield and tensile strengths.	17.0 to 19.0	4.0 to 6.0	0.15 Max.	7.5 to 10.0	1.00 Max.	N 0.25 Max.
301	A variation of 302 which can be cold rolled to high tensile strengths for special applications. It is recommended when higher strengths are required.	16.00 to 18.00	6.00 to 8.00	0.15 Max.	2.00 Max.	1.00 Max.	—
302	This was the original basic austenitic chromium-nickel stainless steel. Along with 304, it is suitable for the widest range of architectural applications. It is easy to fabricate and has excellent weather corrosion resistance.	17.00 to 19.00	8.00 to 10.00	0.15 Max.	2.00 Max.	1.00 Max.	—
304	A low-carbon variation of 302 with similar corrosion resistance. Sometimes specified where extensive welding of heavy sections is needed. It is the type most readily available in many forms; is interchangeable with 302.	18.00 to 20.00	8.00 to 12.00	0.08 Max.	2.00 Max.	1.00 Max.	—
305	An austenitic stainless used for bolts, nuts, screws, and other fasteners.	17.00 to 19.00	10.00 to 13.00	0.12 Max.	2.00 Max.	1.00 Max.	—
316	Austenitic chromium-nickel stainless steel that offers more corrosion resistance through an addition of molybdenum. Recommended for use in salty or corrosive atmospheres.	16.00 to 18.00	10.00 to 14.00	0.08 Max.	2.00 Max.	1.00 Max.	Mo 2.00 to 3.00
410	A chromium stainless steel used for mechanical fasteners.	11.50 to 13.50	0.50 Max.	0.15 Max.	1.00 Max.	1.00 Max.	—
430	A ferritic chromium stainless steel with lower corrosion resistance than the 200 and 300 series; used mainly for interior applications. It can be modified for improved weldability, corrosion resistance, and heat resistance.	14.00 to 18.00	0.05 Max.	0.12 Max.	1.00 Max.	1.00 Max.	—

TABLE 2

	MECHANICAL PROPERTIES (annealed)						PHYSICAL PROPERTIES			TYPE
PRODUCT FORM	YIELD STRENGTH .2% OFFSET LB./IN.² (1,000 psi)	TENSILE STRENGTH LB./IN.² (1,000 psi)	MODULUS OF ELASTICITY LB./IN.² x 10^6	ELONGATION % IN 2 IN.	HARDNESS ROCKWELL B	MELTING RANGE °F	WEIGHT LB./IN.³	THERMAL CONDUCTIVITY BTU/FT²/HR/°F/FT (212°F)	COEFFICIENT OF THERMAL EXPANSION IN./IN./°Fx10^{-6} (32° TO 212°F)	
SHEET	55	115		55	90					
PLATE	—	—	28.6	—	—	—	0.28	9.4	8.7	201
BAR	—	—		—	—					
SHEET	55	105		55	90					
PLATE	—	—	28.6	—	—	—	0.28	9.4	10.2	202
BAR	—	—		—	—					
SHEET	40	110		60	85	2550				
PLATE	40	105	28.0	55	—	to	0.29	9.4	9.4	301
BAR	—	—		—	—	2590				
SHEET	40	90		50	85	2550				
PLATE	35	90	28.0	60	80	to	0.29	9.4	9.6	302
BAR	35	85		60	—	2590				
SHEET	42	84		55	80	2550				
PLATE	35	82	28.0	60	—	to	0.29	9.4	9.6	304
BAR	35	85		60	—	2650				
SHEET	38	85		50	80	2550				
PLATE	35	85	28.0	55	—	to	0.29	9.4	9.6	305
BAR	—	—		—	—	2650				
SHEET	42	84		50	79	2500				
PLATE	36	82	28.0	55	—	to	0.29	9.4	8.9	316
BAR	30	80		60	78	2550				
SHEET	45	70		25	80	2700				
PLATE	35	70	29.0	30	—	to	0.28	14.4	5.5	410
BAR	40	75		35	82	2790				
SHEET	50	75		25	85	2600				
PLATE	40	75	29.0	30	—	to	0.28	15.1	5.8	430
BAR	45	75		30	—	2750				

HARDNESS AND STRENGTH

The tensile strength of annealed chromium nickel stainless steels generally ranges between 80,000 and 110,000 p.s.i. and is accompanied by high ductility. Hardness is related to tensile strength and is generally between 80 and 85 Rockwell B.

Most stainless steels used in architecture and many other applications are annealed. They are then usually given a light cold rolling operation which imparts the final mill finish and improves flatness. This final rolling operation work hardens the stainless slightly, particularly the skin or surface, and accounts for some of the stiffness and springback characteristics usually associated with stainless.

For roofing and flashing applications this springback presents a problem to the mechanic, so a dead soft fully annealed product is also produced by many mills. This product has lower tensile strength (about 80,000 p.s.i.), hardness (about 75 Rockwell B) and minimum springback.

When higher strengths and hardness levels are required for particular structural applications, Type 301 is usually selected as it work hardens more rapidly than other types. When cold rolled to ¼ hard, ½ hard, ¾ hard and full hard tempers, the effect on tensile strength and yield strength is as follows:

TYPICAL PROPERTIES FOR TYPE 301

Temper	Tensile Strength (p.s.i.)	Yield Strength (p.s.i.)
Annealed	110,000	40,000
¼ Hard	125,000	75,000
½ Hard	150,000	100,000
¾ Hard	175,000	135,000
Full Hard	185,000	140,000

The forming characteristics of stainless in these tempers is much different than for annealed stainless and for this reason the architect should not specify them without consulting a stainless steel producer or a qualified fabricator. Without a specification of temper or hardness, annealed stainless will be supplied, which is recommended for most architectural applications.

Structural uses which capitalize on the strength of stainless steel are continually being extended. The trend is toward framing windows and doors in stainless steel formed shapes, rather than merely covering heavier framing members of other metals. Stainless steel frames can be narrow and lightweight, permitting the use of pre-formed glazing gaskets which contribute to the combined fabrication and installation savings that help yield competitive bids.

MILL PRODUCTS

Mill Products

INTRODUCTION

Familiarity with mill products can, in many instances, aid the architect in achieving a simple and economical solution to a design problem.

In this section the many products of the stainless steel producers mills are defined and listed along with the dimensions and finishes in which they are provided.

The products described are limited to those normally used in architecture and generally available from steel service center stocks. Product tables show availability in Types 302 and 304. Other sizes, finishes, alloys and related products may be produced and in some instances stocked, but are not in wide distribution.

For assistance in locating stainless steel items, contact a stainless steel producer or a steel service center. The reader is reminded that the many products of fabricators and specialists, such as roll formers, are not included here.

The nearest office of The International Nickel Company will be pleased to provide assistance in all aspects of stainless steel in architecture, including sources of supply of mill, as well as architectural, products. The INCO offices are listed in the back of this manual.

PLATE

PRODUCT DESIGNATION

Flat rolled or forged products 3/16″ or more in thickness and more than 10″ wide are designated as plate.

AVAILABILITIES

A wide range of plate sizes is stocked by steel service centers throughout the country. The accompanying table cuts off at the ½″ thickness only because heavier plate is seldom specified in architecture. Should the architect require plate of greater thickness, he should inquire about greater availability.

Plate Thicknesses—Plate is readily available in thicknesses from 3/16″ to 3″ and over. Products 3/16″ to ½″ thick are stocked generally in increments of 1/16″.

Plate Width and Lengths—Plate is stocked in standard widths from 36″ through 96″ in 12″ increments. Standard lengths are 120″, 240″ and 360″.

Cutting—Straight shearing cuts are made in plates up to ½″. Plate also is available cut to any shape by burning.

TYPES

The plate availabilities listed are Types 302 and 304. The high-corrosion-resistance Type 316 also is stocked quite widely.

FINISHES

Plate may be specified in the standard hot-rolled, annealed and pickled condition.

Plates are also available from stock with improved surfaces. In this case, the annealed and pickled plate has been given a final cold roll or skin pass.

Producers and fabricators also grind and polish the surface of plate for results similar to stainless steel sheet finishes.

PLATE AVAILABILITIES

Size		Thickness $\frac{3}{16}''$	$\frac{1}{4}''$	$\frac{5}{16}''$	$\frac{3}{8}''$	$\frac{7}{16}''$	$\frac{1}{2}''$
Lbs. per Sq. Ft.*	300 series	7.83	10.44	13.05	15.66	18.27	20.88
	400 series	7.56	10.08	12.60	15.12	17.64	20.16
36 x 96		x	x	x	x		x
120		x	x	x	x		x
240		x	x	x	x		x
48 x 120		x	x	x	x	x	x
240		x	x	x	x	x	x
360		x	x	x			
60 x 120		x	x	x	x	x	x
240		x	x	x	x	x	x
360		x					
72 x 120		x	x	x	x	x	
240		x	x	x	x	x	x
360		x			x		x
84 x 120		x	x	x	x	x	x
240		x	x	x	x	x	x
360		x	x	x	x		x
96 x 120		x	x	x	x	x	x
240		x	x	x	x	x	x
360		x	x		x		x

*Weights are calculated on the basis of 0.29 lb. per cu. in. of chromium-nickel steel or 0.28 lb. per cu. in. of high chromium steel.

SHEET & STRIP

PRODUCT DESIGNATION

Flat rolled products under $\frac{3}{16}$″ thick are designated as sheet or strip. Products 24″ and over in width are referred to as sheet, and most products under 24″ as strip. However, stock under $\frac{3}{16}$″ thick in the standard polished finishes is designated as sheet, regardless of width.

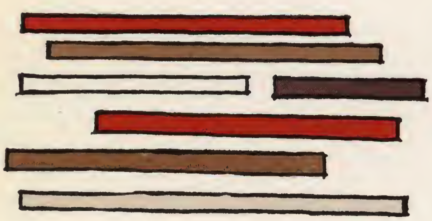
AVAILABILITIES

The accompanying table reflects the wide range of available sizes as stock items carried by some mills and many steel service centers.

Sheet Widths—In most 18 gauge and heavier sheet, the stock widths range from 24″ through 60″ or 72″. In most 20 gauge and lighter sheet, the maximum stock widths are 36″ or 48″. Standard sheet widths increase in increments of 6″.

Sheet Lengths—Sheets 24″ and 30″ wide are offered in lengths of 96″ and 120″. Most wider sheets are available in lengths of 120″ and 144″. Many high-demand sheets are commonly offered in all three lengths: 96″, 120″, and 144″.

Coils—Sheet and strip are widely available in this economical form from which long lengths can be cut. Most availabilities are in the popular 16 to 26 gauge range and widths of 36″ and 48″. Some strip products (widths under 24″) are also stocked, and sheet or strip coils can be slit at the mill or steel service center to obtain narrow widths when required.



TYPES

Types 302 and 304 are the preferred alloys for nearly all exterior stainless steel applications in architecture. Type 304 is the most widely available. Type 316 chromium nickel molybdenum stainless and the straight chromium Type 430 are also widely stocked in many sizes. Many steel service centers also carry a good selection of sheet in Type 301. The 200 Series nickel manganese chromium grades have limited availabilities.

FINISH DESIGNATIONS

The following numbered descriptive system of standard mill finishes, established by the American Iron and Steel Institute, is generally recognized and used:

STANDARD MECHANICAL FINISHES

FINISH	DESCRIPTION
Unpolished Finishes:	
No. 1	A rough dull surface produced by hot rolling to the specified thickness, followed by annealing and descaling.
No. 2D (for widths under 24", referred to as "No. 1 Strip Finish")	A dull finish produced by cold rolling followed by annealing and descaling and sometimes by a final light roll pass on dull rolls.
No. 2B (for widths under 24", referred to as "No. 2 Strip Finish")	A bright cold rolled finish commonly produced in the same way as No. 2D finish, except that the annealed and descaled sheet receives a final light cold roll pass on polished rolls. This is the general purpose cold rolled finish.
No. 2B Bright Annealed	A bright, cold rolled, highly reflective finish is retained in final annealing by a controlled atmospheric furnace.
Polished Finishes:	
No. 3	An intermediate polished surface obtained by finishing with a 100 grit abrasive. Generally used where a semi-finished polished surface is required. It may or may not be additionally polished during fabrication.
No. 4	A polished surface obtained by finishing with approximately a 150 mesh abrasive or finer, following initial grinding with coarser abrasives.
No. 6	A dull satin finish having lower reflectivity than No. 4 finish. It is produced by Tampico brushing the No. 4 finish is a medium of abrasive and oil.
No. 7	A high degree of reflectivity which is obtained by buffing finely ground surfaces but not to the extent of completely removing the "grit" lines. It is used chiefly for architectural and ornamental purposes.
No. 8	The most reflective surface which is obtained by polishing with successively finer abrasives and buffing extensively until all grit lines from preliminary grinding operations are removed. It is used for applications such as mirrors and reflectors.

Samples—Since standard finishes may vary slightly on different products and because of the many non-standard finishes available, the architect may wish to consult producers or fabricators and examine samples before making important finish specifications.

Finish availability — Sheet products are available in all of the AISI standard mechanical finishes. However, No. 2B cold-rolled finish, usually subsequently refinished by the fabricator, and No. 4 polished finish are the most commonly used in architecture and are generally available in stocked sheet. Sheets in some non-standard proprietary finishes are stocked by steel service centers and others are available from mills only. See pages 13 and 14 in the Fabrication Section for a general discussion of these.

SHEET AVAILABILITIES

		Thickness													
Gauge		8	9	10	11	12	14	16	18	20	22	24	26	28	30
Decimal Equivalent		.172	.1562	.1406	.125	.1093	.0781	.0625	.050	.0375	.0312	.025	.0187	.0156	.013
Wt. per	300 series	7.219	6.563	5.906	5.250	4.594	3.281	2.625	2.100	1.575	1.313	1.050	0.788	0.656	0.525
Sq. Ft.*	400 series	7.081	6.438	5.793	5.150	4.506	3.219	2.575	2.06	1.545	1.288	1.030	0.773	0.644	0.515
Size															
24 x 96				x		x	x	x	x	x	x	x	x		
120				x	x	x	x	x	x	x	x	x	x		
30 x 96						x	x	x	x	x	x	x	x	x	
120						x	x	x	x	x	x	x	x	x	
36 x 96				x	x	x	x	x	x	x	x	x	x	x	
120		x	x	x	x	x	x	x	x	x	x	x	x	x	x
144						x	x	x	x						x
42 x 96					x	x	x	x	x	x	x	x	x		x
120					x	x	x	x	x	x	x	x	x		
48 x 96				x	x	x	x	x	x	x	x	x			
120				x	x	x	x	x	x	x	x	x		x	
144		x		x	x	x	x	x	x	x	x	x			
54 x 120					x	x	x	x	x						
56 x 96								x	x						
120								x	x						
60 x 96						x	x	x							
120				x	x	x	x	x	x						
144		x		x	x	x	x	x	x						
72 x 120				x		x		x							
144				x	x	x	x	x							

* Weights are calculated on the basis of 0.29 lb. per cu. inch of chromium-nickel steel or 0.28 lb. per cu. inch of high chromium steel.

BAR

PRODUCT DESIGNATION

Hot Finished Bar—(Hot rolled, forged, or extruded; annealed or heat treated; usually blast cleaned or pickled; rounds may be rough turned or ground) Rounds, squares, hexagons, or octagons ¼″ or over in diameter or size. Flats ⅛″ and over in thickness, ¼″ through 10″ wide.

Cold Finished Bar—(Annealed; rounds drawn or centerless ground; other shapes drawn or cold rolled) Rounds, squares, hexagons, or octagons over ½″ in diameter or size. Flats ⅛″ and over in thickness, ⅜″ through 10″ wide. Smaller size cold finished products, although actually wire, often are listed with bar stocks by the Steel Service Centers.

AVAILABILITIES

Bar products are widely listed in all the standard shapes and finishes. Architectural products normally are fabricated in the following:

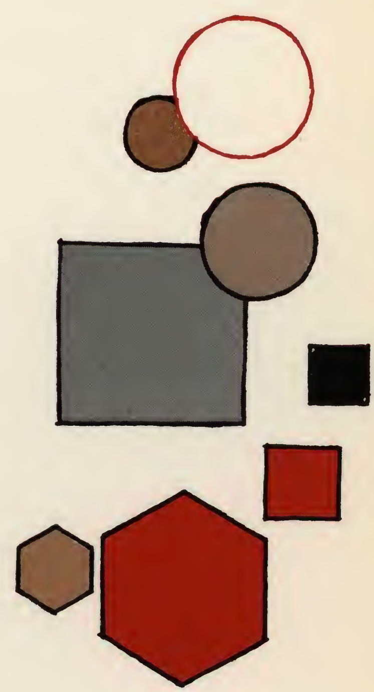
Cold-Finished Flats—An increasing number of Steel Service Centers is stocking a selection of annealed and cold drawn flat bar. Thicknesses of $^3/_{16}$″, ¼″, ½″, and ¾″ are carried. A selection of widths of from ¾″ through 3″ is provided in most of these thicknesses. Exceptions: $^3/_{16}$″ stock starts at ½″, and ¾″ stock is offered in 1″, 1½″, and 2″ widths.

Hot-Finished Flats—A full selection of hot-finished flat bar is stocked throughout the country. Generally it is offered annealed and pickled.

Thicknesses—Flat bars are widely stocked in thicknesses of ⅛″ through 2″. Stocked thicknesses increase by increments of ⅛″ up to around ¾″, then by ¼″.

Widths—A full range of widths from ½″ to 6″ is generally stocked in thicknesses of ¼″ and ⅜″. Thinner stock than this generally runs from ½″ to 3½″ wide. Heavier stock runs from nearly or actually square in each thickness up to 6″ wide. Stock increments of width range from ⅛'s, to ¼'s, to ½'s, to full inches—the larger jumps occurring between the wider sizes, of course.

Lengths—Flat bar lengths vary among warehouses from 10 ft. to over 20 ft.



Cold-Finished Rounds—A very full selection of cold-finished round products is widely available. Although such products under ½″ in diameter actually are wire, Steel Service Centers usually list the bar selection as starting at ⅛″; and generally available sizes run up to 6″. Increments of size are small—all ¹⁄₃₂'s are available through ½″, all ¹⁄₁₆'s through 2″, all ⅛'s through 3″, and all ¼'s through 6″. Stock lengths at different warehouses range from 10 ft. to above 20 ft.

TYPES

The round bar availabilities described above generally are Types 302 and 304 and Type 316; most sizes are found in all three. There is also a good selection in Type 410 and some available sizes in 430.

In flat bar stocks, virtually all sizes are offered in 302 and 304; 316 is stocked in most thicknesses, but not generally in all widths. Availability of 316 in hexagon shapes is excellent—better than 302/304, which are not generally stocked in the wire size range or most sizes between ¾″ and 1¼″.

All of these shapes are produced in a full selection of 302 or 304, plus 316. Your nearest Steel Service Center or stainless steel producer will be glad to assist you in finding any particular size-grade combination needed.

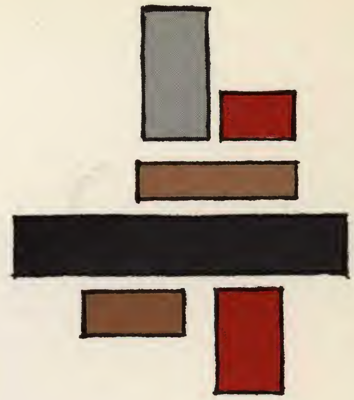
FINISHES

Hot-finished bar should be specified as pickled unless it is to be turned or ground. Blast cleaning can imbed particles in the surface that later produce stains. The wire sizes (½″ and smaller) generally are annealed and cold drawn. The larger sizes, starting with ½″, are annealed and centerless ground.

Cold-Finished Hexagons—A good selection of cold drawn annealed hexagon bar is generally stocked. Widely stocked sizes range from ³⁄₁₆″ wire sizes through 3″. Most ¹⁄₁₆″ increments are generally stocked through 2″.

Cold-Finished Squares—Square cold drawn annealed bar and wire (listed together) are readily to be found in sizes ³⁄₁₆″ through 2″. All ¹⁄₁₆'s are stocked through ½″, most ⅛'s through the larger sizes.

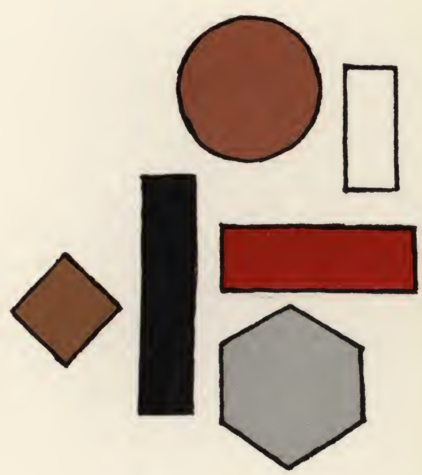
FLAT BAR
Weight in Pounds per Lineal Foot



Width, Inches	Thickness ⅛	3/16	¼	⅜	½	⅝	¾	1
½	0.21	0.32	0.42	0.64				
⅝	0.26	0.40	0.53	0.80	1.06			
¾	0.31	0.48	0.64	0.96	1.27	1.59		
⅞	0.37	0.56	0.74	1.12	1.49	1.86	2.23	
1	0.42	0.64	0.85	1.28	1.70	2.12	2.55	
1¼	0.53	0.80	1.06	1.59	2.12	2.65	3.19	4.25
1½	0.63	0.96	1.28	1.92	2.55	3.19	3.83	5.10
1¾	0.74	1.15	1.49	2.23	2.98	3.72	4.47	5.95
2	0.85	1.28	1.70	2.55	3.40	4.25	5.10	6.80
2½	1.06	1.59	2.12	3.19	4.25	5.31	6.38	8.50
3	1.28	1.91	2.55	3.83	5.10	6.38	7.65	10.20
3½	1.49	2.23	2.98	4.47	5.95	7.44	8.93	11.90
4		2.46	3.40	5.10	6.80	8.50	10.20	13.60
4½			3.83	5.74	7.65	9.57	11.48	15.30
5			4.25	6.38	8.50	10.63	12.75	17.00
6			5.10	7.65	10.20	12.75	15.30	20.40

ROUND, SQUARE, AND HEXAGONAL BAR
Weight in Pounds per Lineal Foot

Size Inches	Rd	Sq	Hex
1/16	.010	.013	....
⅛	.042	.053	.046
3/16	.094	.120	.103
¼	.168	.214	.184
5/16	.262	.334	.287
⅜	.378	.481	.414
7/16	.514	.655	.564
½	.671	.855	.736
9/16	.850	1.08	.932
⅝	1.05	1.33	1.15
11/16	1.27	1.62	1.39
¾	1.51	1.92	1.66
13/16	1.77	2.26	1.94
⅞	2.06	2.62	2.25
15/16	2.36	3.01	2.58
1	2.68	3.42	2.94
1 1/16	3.01	3.84	3.32
1⅛	3.38	4.30	3.73
1 3/16	3.76	4.79	4.15
1¼	4.17	5.31	4.60
1 5/16	4.60	5.86	5.07
1⅜	5.02	6.43	5.57
1 7/16	5.52	7.03	6.08
1½	6.01	7.65	6.62
1 9/16	6.52	8.30	7.19
1⅝	7.05	8.98	7.77
1 11/16	7.60	9.68	8.38
1¾	8.18	10.41	9.02
1 13/16	8.77	11.17	9.67
1⅞	9.39	11.95	10.35
1 15/16	10.02	12.76	11.05
2	10.68	13.60	11.78



WIRE & WIRE CLOTH

PRODUCT DESIGNATION

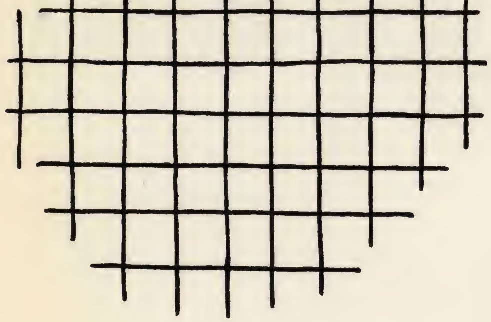
Cold-finished products ½″ and under in round or square, hexagon, octagon, half-round, oval, and other sections identified by a single dimension are referred to, respectively, as round or shape wire. Cold-finished products 0.01″ to under 3⁄16″ thick and 1⁄16″ to under ⅜″ wide are designated as flat wire.

AVAILABILITY AND TYPES

Most sizes and shapes commonly used in architecture are included in the cold-finished bar stock listings by warehouses; see page 7 for a description of these availabilities, ranging upward from ⅛″ diameter or size.

Coils—Coiled round wire, sized in decimals, is stocked. Readily available sizes in Type 302 or 316 range from .007″ through .420″. Coils in Type 430 are listed in sizes .091″ through .220″.

Wire Cloth—Rolls of wire cloth and screening are stocked in stainless steel Type 304 and Type 316. Typical availabilities in 36″ wide rolls are shown in the following table:



WIRE CLOTH

Mesh	Wire Size, Inches	Width of Opening, Inches	Percentage of Open Area
4 x 4	.047	.203	65.9
4 x 4	.035	.215	74.0
5 x 5	.035	.165	68.1
5 x 5	.023	.177	78.3
8 x 8	.032	.093	55.4
8 x 8	.028	.097	60.2
8 x 8	.025	.100	64.0
10 x 10	.032	.068	46.2
10 x 10	.025	.075	56.3
10 x 10	.023	.077	59.3
12 x 12	.023	.060	51.8
12 x 12	.018	.065	60.8
16 x 16	.018	.045	50.7
20 x 20	.016	.034	46.2
24 x 24	.014	.028	44.2
30 x 30	.017	.016	23.9
30 x 30	.012	.021	40.8
40 x 40	.010	.015	36.0
50 x 40	.009	.011	31.7
60 x 50	.0065	.010	39.4
60 x 60	.011	.006	11.7
80 x 70	.0055	.007	34.5
100 x 90	.0045	.006	33.0
150 x 150	.0026	.0041	37.4
180 x 180	.0025	.0031	30.6
200 x 200	.0021	.0029	33.6
325 x 325	.0014	.0017	30.0
400 x 400	.0010	.0015	36.0

TUBING & PIPE

PRODUCT DESIGNATION

Welded or seamless tubular products are designated as tubing or pipe. Tubing is generally thinner-walled and produced to closer tolerances than pipe. Tubing is produced in numerous gauge and decimal size increments, whereas pipe is produced in a limited number of nominal sizes designated by the American Standards Association, with fittings sized to match. Stainless steel pipe size-wall thickness standards are described in ASA B36.19 as Schedules 5S, 10S, 40S, and 80S. Architectural fabricators normally use stainless steel mechanical tubing or ornamental tubing; these are produced in rounds, squares and a range of other shapes.

AVAILABILITIES AND TYPES

Seamless and welded stainless steel tubing and pipe are stocked by Steel Service Centers throughout the country in the full range of sizes and wall thicknesses.

Ornamental Tubing—Although the size selection in this class of tubing is limited, it meets a considerable percent of the architectural needs. Shapes: Ornamental tubing is standard in round, square, rectangular, and flat-oval shapes. Also, it is readily available in true ovals, hexagons, and other shapes. It is welded tubing stocked as cold rolled (O.D.) with the welding flash removed and is stocked or available as polished or as buffed to satin or mirror reflectivity. Ornamental tube is not annealed, but is suitable for a moderate degree of bending. Sizes: Round ornamental is produced in ten increments from ¾″ O.D. through 2″ O.D.; square sizes range from ½″ x ½″ through 4″ x 4″ O.D.; rectangular from ½″ x 1″ through 3″ x 5″. Available flat-oval sizes range from ⅜″ through 2″. Nearly all sizes are offered in wall thicknesses of .035″, .049″, .065″, and .083″. Stainless alloys: Types 301, 302, and 304.

Mechanical Tubing—Round stainless mechanical tubing is generally stocked in outside diameters ranging from 3⁄16″ or less through 8″ or more. Extruded seamless is generally stocked through 6″. Welded seamless is listed through 8⅝″ O.D. Readily available stock O.D. increments run in 1⁄16's through ⅝″, ⅛'s through 1″, and ¼'s through 3¾″. Small increments also often appear among the larger-size listings, but varying larger increments predominate. Standard wall thicknesses are .028″, .035″, .049″, .083″, .120″. Large diameters are matched with wall thicknesses through .625″, but 8¼″ tubing is also stocked with a wall thickness of only .044″. The basic

thicknesses are B. W. Gauge equivalents and are often listed by gauge, but between-gauge thicknesses are scattered throughout the listing. Finishes: Hot-finished, annealed and pickled round stainless tubing and cold-drawn, annealed, and pickled, or bright annealed round tubing are offered in the full range of O.D. sizes. Polished or buffed welded rounds are stocked in the 1″ through 4″ size range. Alloys: Both Type 304 and Type 316 round stainless are widely stocked in the range of sizes. Type 304 is offered in most increments, Type 316 in a good selection. Polished Type 316 tube may not be found in stock, however. Shapes: Stainless mechanical tubing is produced but not generally stocked in squares, rectangles, hexagons, ovals, teardrops, T's, and other section shapes.

Pipe—Stainless steel pipe ⅛″ through 12″ nominal sizes (I.P.S.) in all four stainless ASA wall thickness schedules (5S, 10S, 40S, and 80S) is widely stocked in a full range of increments. Stocked length generally is 20 ft. Standard fittings are available for threaded, slip-on or butt welded application. Finishes: Hot-finished pipe, annealed, and pickled, is stocked in sizes from ⅛″ through 12″ in all schedules. A selection of cold-drawn, annealed, and pickled pipe ranges from ¾″ through 6″ in Schedule 5S, ⅛″ through 4″ in Schedule 10S, ⅛″ through 8″ in Schedule 40S, and ⅛″ through 8″ in Schedule 80S. Alloys: Pipe availabilities in all schedules are primarily in Types 304 and 316.

FINISHES

Seamless tubular products of up to 6″ outside diameter generally are extruded. Products beyond the size capability of extrusion presses are listed as seamless. Products referred to as seamed or welded are roll formed or brake formed from flat stock. With these facts in mind, the architect should specify condition and finish as follows:

Hot Finished—Specify seamless products as annealed and pickled. Specify welded products with weld bead removed and as annealed and pickled.

Cold Drawn—Tubing or pipe drawn through a die which changes the size of the product and gives it a bright finish. This process work hardens the metal. Any weld bead is removed before cold drawing.

As Welded—Cold drawn or cold rolled, with weld bead removed, but not annealed. The tubing has a bright finish and may be in a work hardened condition.

As Extruded—Applies to seamless tubing having a bright cold drawn finish. Usually it is in a work hardened condition. Bright Annealed—A bright cold-drawn finish retained through annealing in a controlled-atmosphere furnace. Specify full-soft or ⅛, ¼, or ½ hard condition.

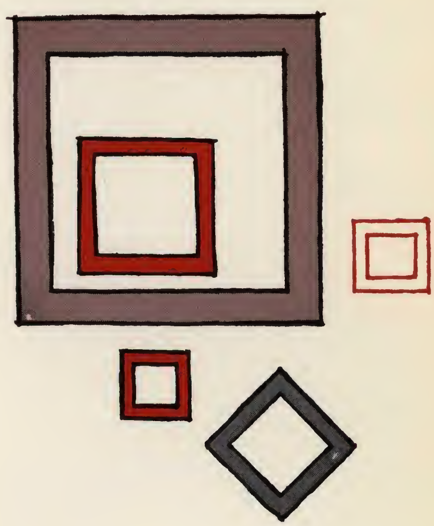
Full Finished—Term applied to welded tubing with weld bead removed and tubing cold drawn, annealed, and pickled. The finish is bright. The architect should specify full-soft or ⅛, ¼, or ½ hard condition.

Polished Finishes—Cold-drawn tubing can be specified as polished or ground with a stated grit size or buffed to a satin or mirror brightness. Specifications should always state the desired condition of softness or hardness of cold-drawn tubing. Note: In mechanical tubing or pipe specify polished finishes as O.D. only, unless you want the inside surface polished. Polished finishes apply to both; certain processing industries often require a polished inside diameter.

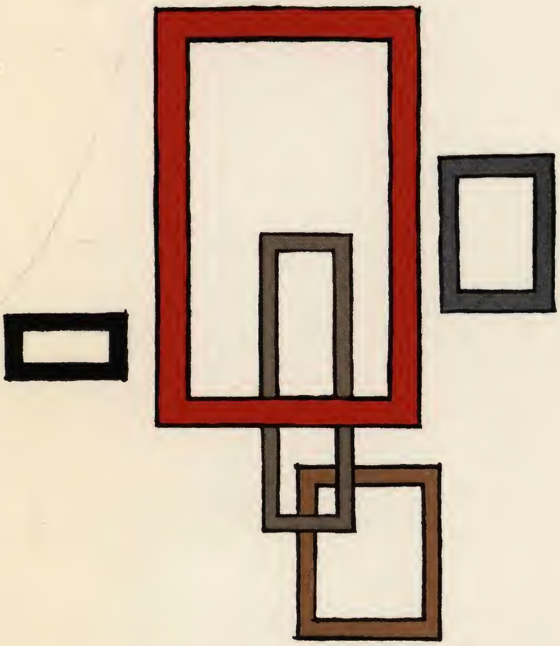
SQUARE TUBING

Weight in Pounds per Lineal Foot

	Wall Thickness							
BW gauge	20	18	16	14	12	11	10	9
OD, Inches								
½ x ½	.221	.301	.385					
⅝ x ⅝	.281	.384	.495	.612				
¾ x ¾	.340	.467	.606	.753				
⅞ x ⅞	.400	.550	.716	.894				
1 x 1	.459	.634	.827	1.035	1.321	1.436		
1⅛ x 1⅛	.519	.717	.937	1.176	1.506	1.640		
1¼ x 1¼	.578	.800	1.048	1.317	1.691	1.844		
1⅜ x 1⅜	.638	.884	1.158	1.458	1.877	2.048		
1½ x 1½	.697	.967	1.269	1.600	2.062	2.252	2.489	
1¾ x 1¾	.816	1.134	1.490	1.882	2.433	2.660	2.945	
1⅞ x 1⅞	.876	1.217	1.600	2.023	2.618	2.864	3.173	3.476
2 x 2	.935	1.300	1.711	2.164	2.803	3.068	3.401	3.728
2¼ x 2¼		1.467	1.932	2.446	3.174	3.476	3.856	4.231
2½ x 2½			2.153	2.728	3.544	3.884	4.312	4.734
2⅝ x 2⅝			2.263	2.869	3.729	4.088	4.539	4.985
3 x 3			2.595	3.293	4.286	4.700	5.223	5.741
3½ x 3½			3.036	3.857	5.027	5.516	6.134	6.747
4 x 4			3.479	4.422	5.768	6.332	7.045	7.753



RECTANGULAR TUBING



	Wall Thickness							
BW gauge	20	18	16	14	12	11	10	9
OD, Inches								
3/8 x 1	.310	.425						
1/2 x 1	.340	.467	.606	.753				
1/2 x 1 1/4	.400	.550	.716	.894				
1/2 x 1 1/2	.495	.634	.826	1.035				
5/8 x 3/4	.311	.426	.550	.682				
5/8 x 1 1/2	.489	.675	.882	1.106	1.414			
5/8 x 2	.608	.842	1.103	1.388	1.784			
3/4 x 1	.400	.550	.716	.894				
3/4 x 1 1/4	.459	.634	.827	1.035				
3/4 x 1 1/2	.519	.717	.937	1.176				
3/4 x 1 3/4		.800	1.047	1.317				
3/4 x 2	.638	.884	1.158	1.458	1.877	2.048		
7/8 x 1 1/4	.489	.675	.882	1.106	1.414			
1 x 1 1/8	.489	.675	.882	1.106				
1 x 1 1/4	.519	.717	.937	1.176	1.506	1.640		
1 x 1 1/2	.578	.800	1.048	1.317	1.691	1.844		
1 x 1 3/4	.638	.884	1.158	1.458	1.877	2.048		
1 x 2	.697	.967	1.269	1.600	2.062	2.252	2.489	
1 x 2 1/2	.816	1.134	1.490	1.882	2.433	2.660	2.945	
1 x 3		1.300	1.711	2.164	2.803	3.068	3.401	
1 x 3 1/2		1.467	1.932	2.446	3.174	3.476	3.856	
1 1/4 x 1 3/4	.697	.967	1.269	1.600	2.062	2.252		
1 1/4 x 2	.757	1.050	1.379	1.741	2.247	2.456		
1 1/4 x 3		1.383	1.821	2.305	2.989	3.272	3.628	3.979
1 1/4 x 3 1/2		1.550	2.042	2.587	3.359	3.680	4.084	4.483
1 1/4 x 4		1.716	2.263	2.869	3.729	4.088	4.539	4.995
1 3/8 x 1 1/2		.661	1.213	1.528	1.969	2.150		
1 3/8 x 6 3/8			3.368	4.280	5.582	6.128	6.817	7.501
1 1/2 x 2	.816	1.134	1.490	1.882	2.433	2.660		
1 1/2 x 2 1/4		1.217	1.600	2.023	2.618	2.864	3.173	3.476
1 1/2 x 2 1/2		1.300	1.711	2.164	2.803	3.068	3.401	3.728
1 1/2 x 3		1.467	1.932	2.446	3.174	3.476	3.856	4.231
1 1/2 x 3 1/2		1.633	2.153	2.728	3.544	3.884	4.312	
1 3/4 x 2		1.217	1.600	2.023	2.618	2.864	3.173	3.476
1 3/4 x 4		1.883	2.484	3.151	4.100	4.496	4.995	5.488
2 x 3		1.633	2.153	2.728	3.544	3.884	4.312	4.734
2 x 4			2.595	3.293	4.286	4.700	5.223	5.741
2 x 5			3.037	3.857	5.027	5.516	6.134	6.747
2 1/2 x 3			2.374	3.011	3.915	4.292	4.767	5.237
2 1/2 x 4			2.816	3.575	4.656	5.108	5.679	6.244
2 1/2 x 5			3.258	4.139	5.397	5.924	6.590	7.250
3 x 3 1/2			2.816	3.575	4.656	5.108	5.679	6.244
3 x 4 (indented)			3.037	3.857	5.027	5.516	6.134	6.747
3 x 4			3.037	3.857	5.027	5.516	6.134	6.747
3 x 5			3.479	4.422	5.768	6.332	7.045	7.753

Approximate Weight/Pounds per lineal foot — Indicated in each column
(Weights are based on formula using density of carbon steel)
All sizes available in types 302 and 304

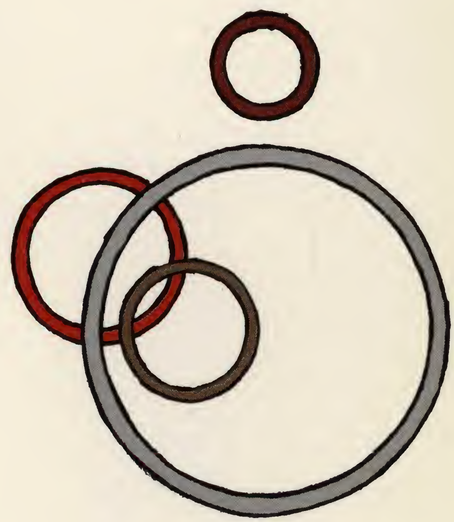
IRON PIPE SIZES

Iron Pipe Size, In.	Pounds per Foot	Diameter, In. OD	Diameter, In. ID	Wall Thick., Inches
SCHEDULE 5 LIGHT WALL IRON PIPE SIZES				
¾	.684	1.050	.920	.065
1	.868	1.315	1.185	.065
1¼	1.107	1.660	1.530	.065
1½	1.274	1.900	1.770	.065
2	1.604	2.373	2.245	.065
2½	2.475	2.875	2.709	.083
3	3.029	3.500	3.334	.083
3½	3.505	4.000	3.834	.083
4	3.195	4.500	4.334	.083
6	7.585	6.625	6.407	.109
8	9.914	8.625	8.407	.109
SCHEDULE 10 LIGHT WALL IRON PIPE SIZES				
½	.671	.840	.674	.083
¾	.857	1.050	0.884	.083
1	1.404	1.315	1.097	.109
1¼	1.806	1.660	1.442	.109
1½	2.085	1.900	1.682	.109
2	2.638	2.375	2.157	.109
2½	3.531	2.875	2.635	.120
3	4.332	3.500	3.260	.120
3½	4.973	4.000	3.760	.120
4	5.613	4.500	4.260	.120
6	.929	6.625	6.357	.134
8	13.40	8.625	8.329	.148
10	18.65	10.750	10.420	.165
SCHEDULE 40 STANDARD IRON PIPE SIZES				
⅛	.245	.405	.269	.068
¼	.425	.540	.364	.088
⅜	.568	.675	.493	.091
½	.851	.840	.622	.109
¾	1.131	1.050	.824	.113
1	1.679	1.315	1.049	.133
1¼	2.273	1.660	1.380	.140
1½	2.718	1.900	1.610	.145
2	3.653	2.375	2.067	.154
2½	5.790	2.875	2.469	.203
3	7.580	3.500	3.068	.216
3½	9.109	4.000	3.548	.226
4	10.790	4.500	4.026	.237
5	14.620	5.563	5.047	.258
6	18.970	6.625	6.065	.280
8	28.550	8.625	7.981	.322
SCHEDULE 80 EXTRA HEAVY IRON PIPE SIZES				
⅛	.315	.405	.215	.095
¼	.535	.540	.302	.119
⅜	.739	.675	.423	.126
½	1.088	.840	.546	.147
¾	1.474	1.050	.742	.154
1	2.172	1.315	.957	.179
1¼	2.997	1.660	1.278	.191
1½	3.631	1.900	1.500	.200
2	5.022	2⅜	1.939	.218
2½	7.661	2⅞	2.323	.276
3	10.250	3½	2.900	.300
3½	12.510	4.000	3.364	.318
4	14.980	4.500	3.826	.337
5	20.780	5.563	4.813	.375
6	28.570	6.625	5.761	.432
8	43.490	8.625	7.625	.500

ROUND TUBING

OD, Inches	Wall Thickness B.W. Ga.	Wall Thickness Dec. Equiv.	ID, Inches	Pounds per Foot
1/8	x 22	.028	.069	.0290
3/16	x 22	.028	.131	.0478
	20	.035	.117	.0572
1/4	x 22	.028	.194	.0664
	20	.035	.180	.0804
	18	.049	.152	.1052
	16	.065	.120	.1284
5/16	x 20	.035	.242	.1039
	18	.049	.214	.1382
	16	.065	.182	.1722
3/8	x 22	.028	.319	.1038
	20	.035	.305	.1271
	18	.049	.277	.1706
	16	.065	.245	.2152
7/16	x 20	.035	.367	.1506
	18	.049	.339	.2036
	16	.065	.307	.2589
1/2	x 20	.035	.430	.1738
	18	.049	.402	.2360
	16	.065	.370	.3020
	13	.095	.310	.4109
	11	.120	.260	.4870
5/8	x 20	.035	.555	.2205
	18	.049	.527	.3014
	16	.065	.495	.3888
	11	.180	.385	.6472
3/4	x 20	.035	.680	.2673
	18	.049	.652	.3668
	16	.065	.620	.4755
	14	.083	.584	.5913
	13	.095	.560	.6646
	11	.120	.510	.8074
7/8	x 20	.035	.805	.3140
	18	.049	.777	.4323
	16	.065	.745	.5623
	11	.120	.635	.9676
1	x 20	.035	.930	.3607
	18	.049	.902	.4977
	16	.065	.870	.6491
	14	.083	.834	.8129
	13	.095	.810	.9182
	11	.120	.760	1.128
	3/16	.187	.625	1.630
	1/4	.250	.500	2.003
1 1/4	x 20	.035	1.180	.4542
	16	.065	1.120	.8226
	14	.083	1.084	1.034
	11	.120	1.010	1.448
	3/16	.187	.875	2.132
	1/4	.250	.750	2.670
1 3/8	x 16	.065	1.245	.9094
1 1/2	x 20	.035	1.430	.5476
	18	.049	1.402	.7593
	16	.065	1.370	.9962
	14	.083	1.334	1.256
	11	.120	1.260	1.769
	3/16	.187	1.125	2.634
	1/4	.250	1.000	3.338
1 5/8	x 16	.065	1.495	1.083

OD, Inches	Wall Thickness		ID, Inches	Pounds per Foot
	B.W. Ga.	Dec. Equiv.		
1¾	x 18	.049	1.652	.8902
	16	.065	1.620	1.170
	14	.083	1.584	1.478
	11	.120	1.510	2.089
	3⁄16	.187	1.375	3.136
1⅞	x 13	.095	1.685	1.806
2	x 20	.035	1.930	.7345
	18	.049	1.902	1.021
	16	.065	1.870	1.343
	14	.083	1.834	1.699
	11	.120	1.760	2.409
	3⁄16	.187	1.625	3.638
	¼	.250	1.500	4.673
2¼	x 16	.025	2.120	1.517
	11	.120	2.010	2.730
	3⁄16	.187	1.875	4.140
	¼	.250	1.750	5.340
2⅜	x 16	.065	2.245	1.604
	12	.109	2.157	2.638
	.154	.154	2.067	3.653
	.218	.218	1.939	5.022
2½	x 18	.049	2.402	1.283
	16	.065	2.370	1.690
	14	.083	2.334	2.143
	11	.120	2.260	3.050
	¼	.250	2.000	6.008
2¾	x 16	.065	2.620	1.864
	11	.120	2.510	3.371
2⅞	x 11	.120	2.635	3.531
	.203	.203	2.469	5.793
	.276	.276	2.323	7.661
3	x 16	.065	2.870	2.037
	14	.083	2.834	2.586
3	11	.120	2.760	3.691
	3⁄16	.187	2.625	5.646
	¼	.250	2.500	7.343
3¼	x 11	.120	3.010	4.011
3½	x 16	.065	3.370	2.385
	14	.083	3.334	3.029
	11	.120	3.260	4.332
	.216	.216	3.068	7.576
	.300	.300	2.900	10.25
3¾	x 11	.120	3.510	4.652
4	x 16	.065	3.870	2.732
	14	.083	3.834	3.472
	11	.120	3.760	4.973
	3⁄16	.187	3.625	7.654
	.226	.226	3.548	9.109
	.318	.318	3.364	12.51
4½	x 11	.120	4.260	5.613
	.237	.237	4.026	10.79
	.337	.337	3.826	14.98
5 9⁄16	x .258	.258	5.047	14.62
	⅜	.375	4.813	20.78
6⅝	x .280	.280	6.065	18.97
	.432	.432	5.761	28.57
8⅝	x .322	.322	7.981	28.55
	½	.500	7.625	43.49



ROLLED & EXTRUDED STRUCTURALS

PRODUCT DESIGNATION

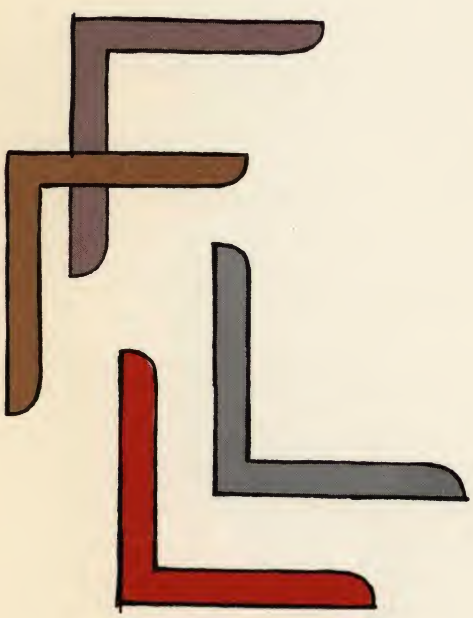
Angles, channels, Tees, I beams, and H beams are produced in stainless steel. Precisely speaking, shapes are "Structural" when at least one cross-sectional dimension is 3″ or larger; smaller shapes are referred to as "bar size shapes."

AVAILABILITIES

The following dimension-weight tables reflect the availabilities of stock items. Random lengths of about 20 ft. are generally stocked. Steel Service Centers stock primarily the hot-rolled and extruded equal-leg angles sizes listed. The other extruded shapes are stocked or readily produced to order by mills with extrusion presses. Cold-rolled angles and channels are stocked by suppliers of architectural metals components. For assistance in locating any item, contact a stainless steel producer of rolled or extruded products or Steel Service Centers.

TYPES

Equal-leg angles, as shown, are widely available hot rolled in Types 302 and 304 and in Type 316. Extruded equal-leg angles are stocked in Types 304 and 316. The other structural shapes are available primarily in Type 304. Producers are showing interest in providing these shapes in Type 316.



FINISHES

In stainless steel, Tees and beams are produced by extrusion only; channels and angles are produced by extrusion, hot rolling, or cold rolling.

Extrusions—These characteristically have rounded outside and inside corners and edges and have flat surfaces. However, some channels, Tees, and beams are produced to match standard hot rolled sections, which are tapered. Limitations are as follows:

The maximum diameter of the smallest circle that will encompass the cross-section of the shape is 5⅜″.

Straight lengths up to 60 ft. can be produced. Lengths up to 28 ft. can be deglassed and heat treated. (Molten glass is used as a lubricant in extruding.)

The depth of an indentation can be no greater than its width.

The minimum web thickness is about 0.125″, varying slightly with alloys. The maximum ratio of cross-section length to cross-section thickness for each segment of section is 14 to 1.

Normal radius of outside corners and edges is about .062″. Normal radius of fillets or inside corners is about 0.250″.

The minimum cross-section area is 0.280 sq. in. The maximum product weight is about 25 lbs. per ft., varying slightly with alloys.

Hot-Rolled Shapes—These are characterized by sharp, short-radius outside corners and flat outside surfaces, along with rounded inside corners and surfaces. Inside surfaces of angles taper to give a thicker section at the bend than near the edges; on channels, the middle or web section, is flat on both sides, the flanges rounded and tapered on the inner side. Hot-rolled shapes should be specified as annealed and pickled.

Cold-Rolled Shapes—Cold-rolled angles and channels are produced by bending cold-rolled stainless steel sheet. The resulting section has rounded outside corners, sharp inside corners, flat surfaces, and square edges. The smooth-rolled finish is suitable for polishing.

ANGLES
Extruded

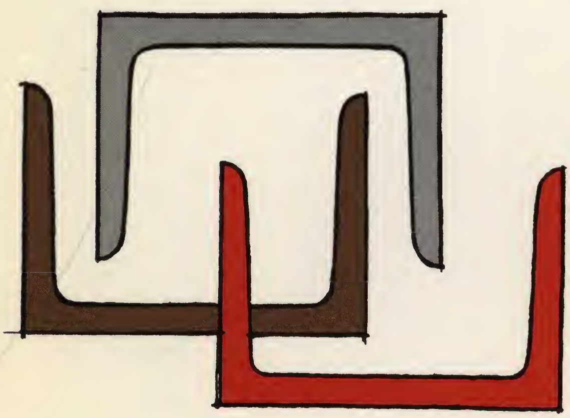
Size, Inches	Pounds per Foot	Size, Inches	Pounds per Foot
Unequal Leg		Equal Leg	
a b c		a b c	
2 x 1 x 3/16	1.75	1 x 1 x 3/16	1.15
2 x 1½ x 3/16*	2.12	1¼ x 1¼ x 3/16	1.48
2½ x 2 x 3/16	2.75	1½ x 1½ x 3/16	1.80
3 x 2 x 3/16	3.07	1¾ x 1¾ x 3/16	2.12
		2 x 2 x 3/16	2.44
2 x 1 x ¼	2.35	2½ x 2½ x 3/16	3.07
2 x 1½ x ¼	2.78	3 x 3 x 3/16	3.71
2½ x 1¼ x ¼	2.85		
2½ x 1½ x ¼	3.19	1 x 1 x ¼	1.49
2½ x 2 x ¼	3.62	1¼ x 1¼ x ¼	1.92
3 x 1½ x ¼	3.51	1½ x 1½ x ¼	2.38
3 x 2 x ¼**	4.10	1¾ x 1¾ x ¼	2.75
3½ x 2½ x ¼	4.90	2 x 2 x ¼	3.19
3½ x 3 x ¼	5.40	2½ x 2½ x ¼	4.10
4 x 3 x ¼	5.80	3 x 3 x ¼	4.90
		3½ x 3½ x ¼	5.80
2½ x 1½ x ⅜	4.70		
2½ x 2 x ⅜	5.30	2 x 2 x 5/16	3.92
3 x 1½ x ⅜	5.30	2½ x 2½ x 5/16	5.00
3 x 2 x ⅜	5.90	3 x 3 x 5/16	6.10
3½ x 2½ x ⅜	7.23		
3½ x 3 x ⅜	7.90	2 x 2 x ⅜	4.70
4 x 3 x ⅜	8.50	2½ x 2½ x ⅜	5.90
		3 x 3 x ⅜	7.20
3 x 1 x ½	6.01	3½ x 3½ x ⅜	8.50
3 x 2 x ½**	7.70		
3½ x 1½ x ½	7.64	3 x 3 x ½	9.40
3½ x 3 x ½	10.20	3½ x 3½ x ½	11.10
4 x 3 x ½	11.10		

"I" BEAMS
Extruded

Size, Inches	Pounds per Foot	Size, Inches	Pounds per Foot
1½ x 1 x 3/16	2.02	3 x 2⅜ x ¼	6.60
2 x 1¼ x ¼	3.43	4 x 2¾ x ¼	8.32
2½ x 1½ x ¼	4.22		

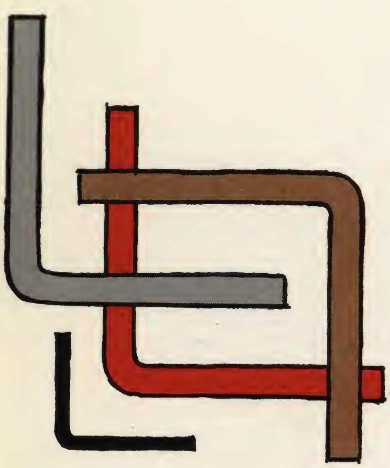
"T's"
Extruded

Size, Inches	Pounds per Foot	Size, Inches	Pounds per Foot
1 x 1½ x 3/16	1.48	1½ x 2½ x ¼	3.19
1¼ x 1¼ x 3/16	1.48	2 x 1½ x ¼	2.75
2 x 1¼ x 3/16	1.96	2 x 2 x ¼	3.19
1½ x 1½ x 3/16	1.65	2½ x 2½ x ¼	4.10
2⅜ x 1½ x 3/16	2.36	2½ x 2½ x ⅜	5.90
1¼ x 1 x ¼	1.71	3 x 2½ x ⅜	6.70
1¼ x 2 x ¼	2.57	4 x 3½ x 5/16	7.66



CHANNELS
Hot Rolled (Annealed and Pickled) & Extruded

Size, Inches	Pounds per Foot	Size, Inches	Pounds per Foot
1 x ½ x ⅛	0.75	1½ x 1 x ¼	2.57
1½ x ½ x ⅛	0.96	2 x ⅝ x ¼	2.35
2½ x ⅝ x 3/16	2.28	2 x 1 x ¼	3.15
1½ x ¾ x 3/16	1.75	2½ x 1 x ¼	3.57
2 x ¾ x 3/16	2.02	3 x 1½ x ¼	4.75
3 x 1⅜ x 3/16	4.10	4 x 1¾ x ¼	6.69
1¼ x 1 x ¼	2.35		



COLD ROLLED ANGLES
Square Root and Square Edge

Size, Inches	Pounds per Foot	Size, Inches	Pounds per Foot
Equal Legs		1½ x 1½ x ⅛	1.23
½ x ½ x ⅛	0.38	1½ x 1½ x 3/16	1.80
⅝ x ⅝ x ⅛	0.48	2 x 2 x ⅛	1.65
¾ x ¾ x 1/16	0.39	2 x 2 x 3/16	2.44
¾ x ¾ x ⅛	0.59	Unequal Legs	
1 x 1 x ⅛	0.80	1 x ⅝ x ⅛	0.64
1 x 1 x 3/16	1.16	1¼ x ¾ x ⅛	0.80
1¼ x 1¼ x ⅛	1.01	1½ x 1 x ⅛	1.01
1¼ x 1¼ x 3/16	1.48	2 x 1 x ⅛	1.23

COLD ROLLED CHANNELS
Square Root and Square Edge

Size, Inches	Pounds per Foot	Size, Inches	Pounds per Foot
Equal Sides		Unequal Sides	
a b c		a b c	
½ x ½ x .093	0.40	⅝ x 5/16 x .078	0.29
¾ x ¾ x .093	0.57	¾ x ⅜ x .083	0:40
1 x 1 x .109	1.03	1½ x 1 x .109	1.22
1¼ x 1¼ x .109	1.32	1¾ x 1⅛ x .109	1.40
1½ x 1½ x .109	1.59	2 x 1 x .125	1.59
2 x 2 x .125	2.41	2⅜ x 2 3/16 x .156	3.41

FABRICATION

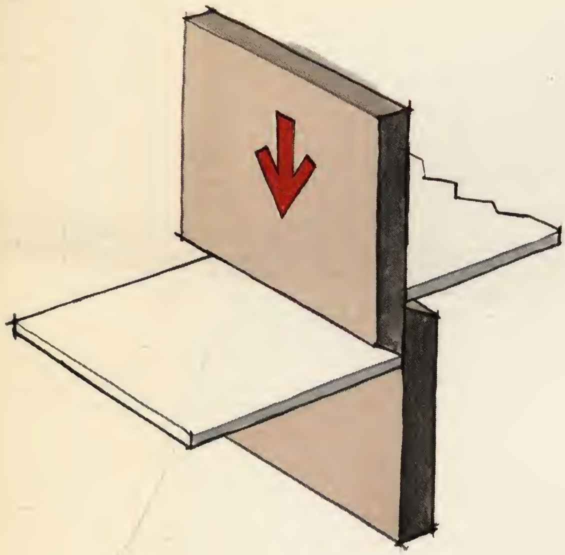
Fabrication

INTRODUCTION

The difficulties of fabricating stainless steel are somewhat exaggerated in the minds of many people. Actually the cutting, forming, joining and finishing of austenitic grades of stainless steel for architecture are accomplished largely with the same equipment and methods used for mild carbon steel. Some processes, such as welding, are occasionally easier with stainless. Properly equipped and experienced fabricators are available in all parts of the country, readily able to satisfy the designer's requirements.

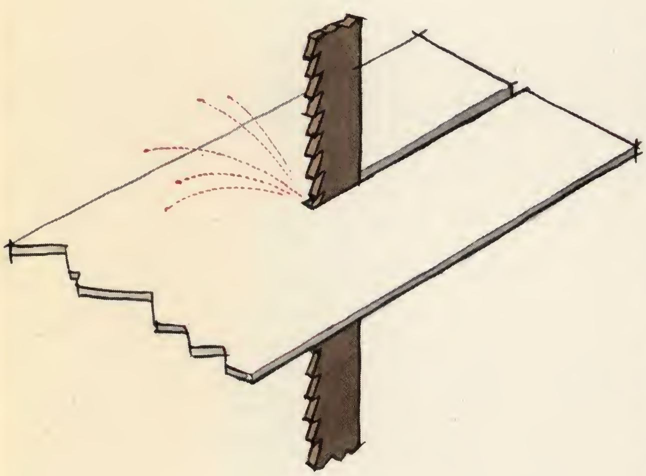
However, there are various details of fabrication well worth noting from the viewpoints of economy and protection of both appearance and properties, as well as from the general viewpoint of design possibilities and limitations. The following is a brief, practical-level presentation of the chief factors that are special to the fabrication of stainless steel for architecture. Several relatively new techniques are included.

CUTTING



For architectural applications stainless steel normally is cut to dimension by shearing, sawing, abrasive cutting, blanking, perforating or nibbling.

SHEARING: Shearing is the fastest method for obtaining straight cuts of coil, sheet and light plate stock. It is accomplished on the same equipment used for carbon steel. Because of the toughness of stainless steel, however, the equipment capacity required in relation to thickness of the material is from thirty to fifty per cent greater.
To insure clean cuts, blades of high-speed steel are maintained sharp and are set with minimum clearance.
Hold-downs are needed in shearing stainless steel. To protect pre-finished material, a thickness of paper, tape or other padding is used under the work and under the hold-downs. Rotary shearing allows contoured cuts.



SAWING: In general, sawing techniques apply to bar stock, to tubing, to cuts across narrow widths of sheet or coil stock, and to trimming. Conventional hack saws, band saws, and friction saws are used, with blades recommended by the manufacturers.

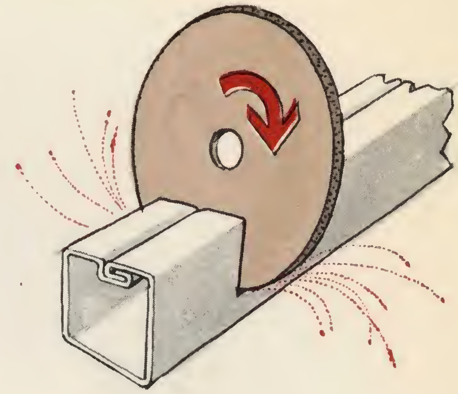
Hand or machine hack saws are operated at only forty to fifty strokes per minute. The chipping action of the saw teeth is maintained at all times by light, steady feed and a well sharpened blade. Any riding of the teeth over the cut can cause work hardening, which greatly slows down the cutting rate; therefore, the hack saw blade must clear the work on the return stroke.

Conventional band saw cutting is done with a sharp blade operated at slow speed and with a light, steady rate of feed.

In friction sawing, the band saw blade travels at extremely high speed (5,000-15,000 fpm), creating sufficient heat to soften the metal for easier removal. This technique produces considerably quicker cutting, and the sharpness of the blade is less critical than with other methods. A burr may appear on the edges of the cut, requiring an extra operation for removal, but the method usually saves time on the whole and is generally applicable to the thicknesses of stock used in architecture. Conventional sawing may prove more efficient, however, where flat pieces can be stacked and sawed several at a time. Friction sawing does not adapt well to this time-saver.

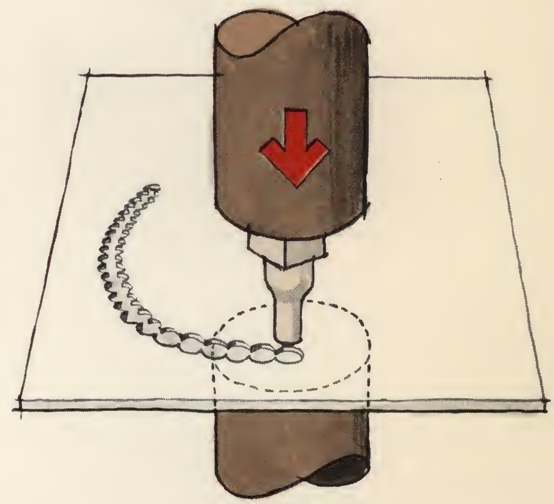
A limited degree of contour cutting can be done on the band saw, operated at either conventional or friction-sawing speed.

ABRASIVE CUTTING: Excellent production cutting results are obtained with abrasive wheels or cutoff discs of various diameters used like circular saw blades. These make fast, smooth, accurate cuts in virtually all architectural stainless steel shapes. Unlike the band saw, the disc can be used to make a slot or groove, without cutting all the way through a piece of tubing or plate. Proper use of coolant obviates any risk of heat damage to the material. Only straight cuts can be made.



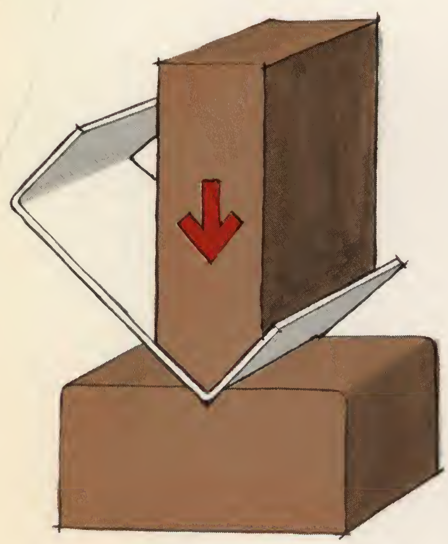
BLANKING, PERFORATING, NIBBLING: Contoured pieces or openings are punched out of stainless steel stock with equipment of the same type used on carbon steel. With austenitic grades, about fifty per cent more power is required for a given operation; cuts are made at reduced speed, with the punch traveling all the way through; and clearance between punch and die is held to five per cent of metal thickness on closed perimeters or ten per cent on open cuts. For thicknesses under twenty gauge, closer tolerances may be required. Raked punches are sometimes used for easier cutting. In perforating, angular shear edges are placed on the punch. Multiple holes are made simultaneously, but the punches may be arranged in step formation. The minimum distance allowed between holes in blanking and perforating is half of the hole diameter.

Nibbling, however, is a specialized operation in which a line of small over-lapping holes are punched to cut contours from sheet metal. Nibbling machines handle austenitic grades of steel in thicknesses through 5/16″. Various nibbling die shapes are available to provide optimum combinations of speed and smoothness of cut under various conditions. Nibbling helps make it practical for the architect to design shapes not suitable for cutting on the band saw.



FORMING

Many hot and cold formed stainless steel shapes are available from the mills and metal fabricators, including those who specialize in roll forming or in extrusions. For the sake of convenience and economy, the architect may want to use these shapes. An infinite variety of shapes and bends, however, are readily produced to specification by the metal fabricating contractor or by production specialists. Forming methods include brake forming, roll forming, roll bending, extruding and others.



BRAKE FORMING: Conventional press brakes make stainless steel bends with few limitations. Power operated and small hand brakes are basic equipment in most fabricating shops and are the means most commonly used to provide specified bends. Press brakes use low-cost or general purpose dies and are thus economical for small jobs and also can be employed for production quantities. Many brakes can accommodate sheet up to 24 feet long, or can yield fast production through gang bends of smaller pieces.

Austenitic stainless grades require about twice the power capacity in relation to thickness required by low carbon steel but widely available brakes handle the range of heavier gauges normally used in architecture. Simultaneous multiple bends frequently are used to produce channels and other such deep section shapes not obtainable by other fabricating equipment.

Since austenitic steels tend to work-harden in the bend, some problem exists in maintaining close tolerances in flat planes between separate bends. However, brake press dies making simultaneous compound bends work the entire surface together and are highly successful in maintaining flatness.

As with any metal, selection of the stock and design of the bend or bends should be considered together. The austenitic fully annealed steels are ductile; in thin gauges, bends with a zero inside radius can be obtained without cracking, and flanges can be as narrow as ¼″ when standard V-dies are used. Even in the annealed condition, however, thicker gauges or acute angles of bending may impose the requirement of a wider radius up to 1½ times T (thickness). With hardened tempered stainless steels, considerably wider radiuses may be needed up to six T and flanges up to ⅜″ wide will be needed. In case of doubt, test bends should be made. The following table may be helpful to the designer considering the relation between the shape he wants and the material he will specify.

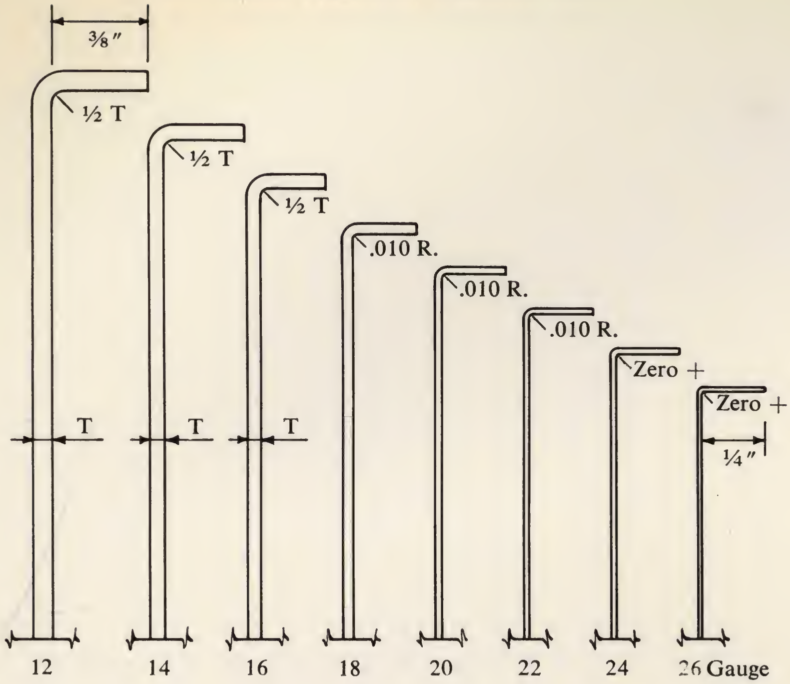
MINIMUM BEND RADII FOR AUSTENITIC STEELS

ANNEALED	
	0*—1½ T
WORK-HARDENED	
¼ Hard	1—2 T
½ Hard	2½—4 T
Full Hard	4—6 T

T—Metal Thickness

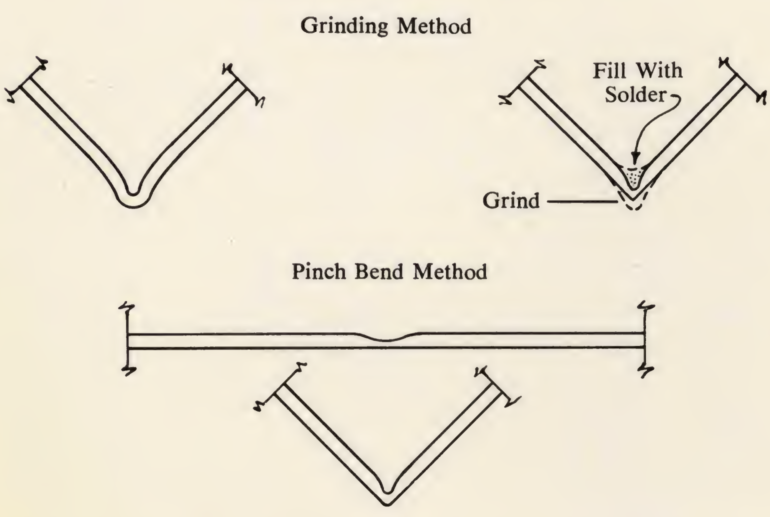
*Male dies used on press brakes always have sharpness removed. The existing radius on the male die edge governs the inside minimum radius obtainable.

90° Bends Annealed Stainless Steel



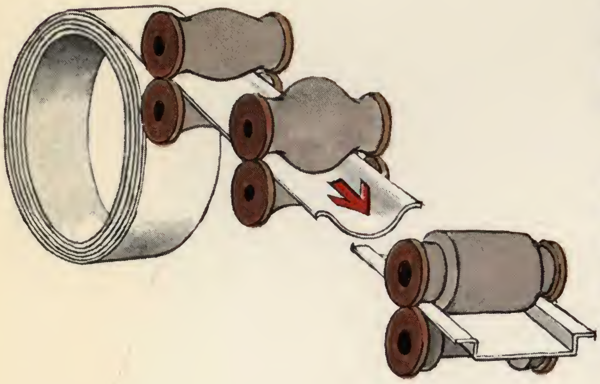
A wide inside radius, of course, produces a rounded outside corner. Corners can be sharpened by pinch-bending or by grinding, but both of these procedures reduce corner strength. Where only the outside of a corner is to be exposed, it can be restrengthened with a bead of solder, laid along the inside.

Brake-Formed Pinched Bends



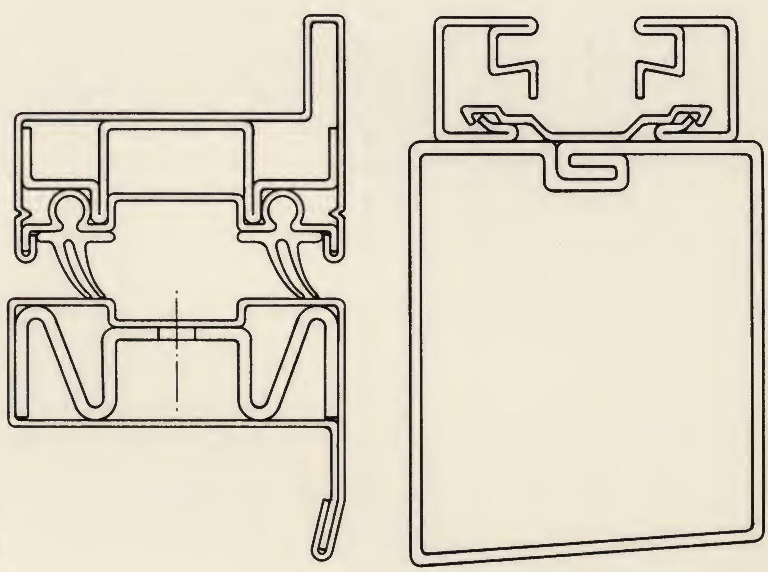
Steel dies should be polished and kept free of imperfections to avoid damaging the finish. Protective tape, or a coating, on pre-finished surfaces is generally used. A neoprene female die can be used which eliminates the possibility of scoring. For short runs, this may also save tooling costs.

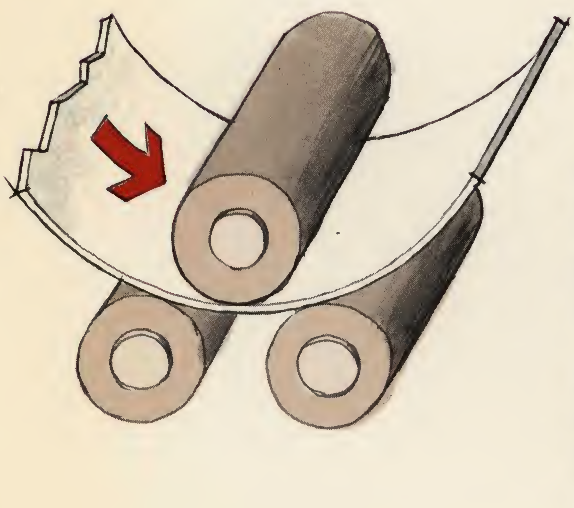
ROLL FORMING: Roll forming is the process of molding light metal sections on a series of small rolling mills mounted in tandem. Profiled mating rolls progressively shape the stock. Each station can increase the depth of bend section a maximum of about ¼″ or add further bends to the metal. A great range of shapes can be attained with accuracy. Fast production rates and use of economical coil stock yield important savings on large runs. Even on small quantities, a simple profile or roll modification requiring few rolls can be economical.



Inside radius limitations are approximately the same as for press brake bending, but complex sections are more readily attained. For example, welded tubing is produced by roll forming. A sharp outside corner can be shaped by the outside die and very narrow flanges (1½ to 2T) can be obtained. Lock seaming and perforating may also be performed in the roll forming operation.

Examples of Roll Formed Shapes





Before specifying a shape to be roll formed, the architect may want to make a thorough study of stock or standard roll formed shapes available in stainless steel. Shapes originated for a wide range of industries are shown in fabricators catalogs. In addition, existing dies can be utilized for shapes not actually in stock.

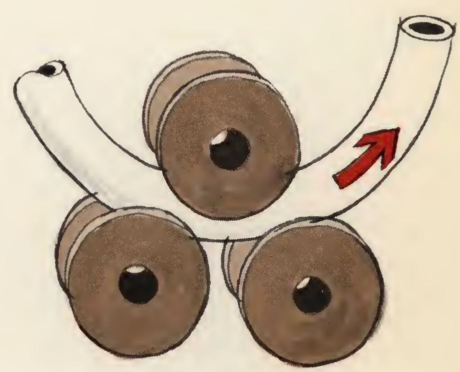
ROLL BENDING: The roll bending machine makes curved shapes, usually in heavy-gauge stock. This, for example, is how cylindrical tanks and cone shapes are formed. The machine consists of three opposing rolls, adjustable to induce the desired degree of bend.

TUBE BENDING: As with other bending operations the same equipment used for bending carbon steel tubing applies to austenitic stainless steel, with about twice the power requirement in relation to size of stock.

There are basic limitations in bending any metal tube: the outside of the bend must stretch and thin; the inside metal must compress; and a tendency exists for the tube structure to buckle or collapse. The thicker the walls of the tube in relation to the diameter, the more "structural stability" it is said to have and the fewer problems it presents.

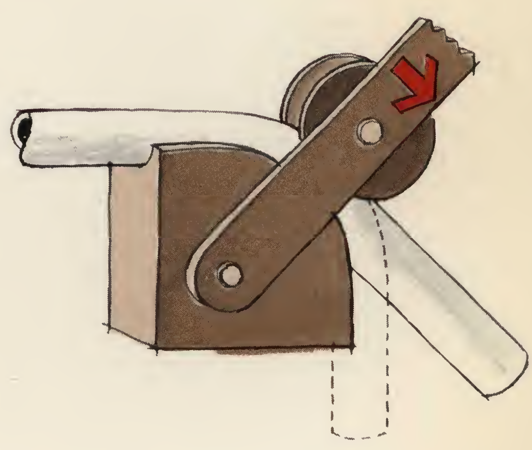
Relatively stable pipe and tubing can be successfully bent through 120 degrees or more in a simple Three-Die press. This consists of two supporting dies with an opposing punch exerting pressure between them. All three dies are shaped to the outside diameter of the tube. The tube may be supported internally with sand, or Wood's Metal, if there is any tendency to collapse. Generally, bend radius can be decreased from six to four times the outside diameter with the use of filling material.

For greater accuracy in bending and for faster production, as well as necessary protection of less stable tubing, other methods are used that both work the inside and outside metal as the bend progresses. These methods are referred to as roll, fixed-die, and rotating-die bending.

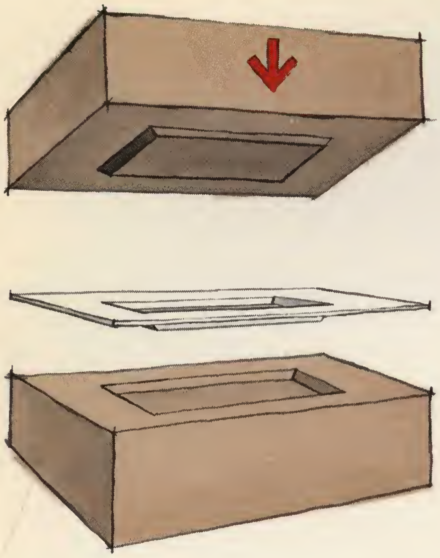


TUBE ROLL BENDING: This is accomplished on equipment similar to that used for flat roll bending, with the stock passing between three rotating dies, one of which is adjustable to establish the degree of bend. All three are contoured to fit the work, which traverses the machine. Complete circles, spirals, and single lengths containing various bends can be produced. Filling is required for light-walled tubes. A bend radius of six times the outside diameter can be readily produced.

Bends as small as three times diameter are made on Fixed-Die equipment. In this case, one end of the work is clamped in place and the free end "wiped" around a stationary die, by one or more rolling dies passed over the outside of the bend. All dies are contoured to fit. Filling may be required.



ROTATING-DIE BENDING: The die shaping the inside of the bend rotates to "wrap itself" in the tube in this process. One end of the tube, clamped to the rotating die, draws the tube around the bend. At the bending point, the outside of the tube is supported by a moving block that advances with the work. If internal support is needed it is provided by a mandrel, the rounded end of which remains at the bending point. In some cases a jointed "ball" extension of the mandrel reaches into the bend, giving further support. An advantage of this method is that there is virtually no sliding action between the dies and the external surface of the work. The shortest bend radii can be obtained with this type of equipment; and it also is used for bending tubes of shapes other than round.

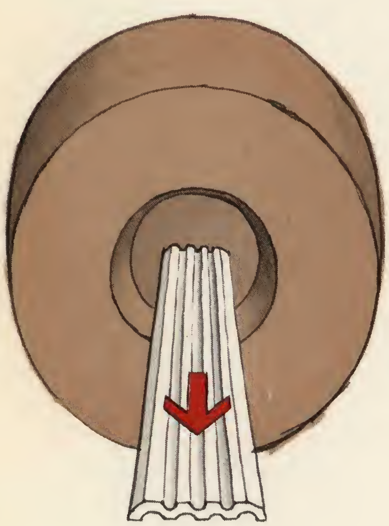


BENCH DRAWING: This is a process commonly used in Canada and Europe which involves drawing stainless steel over a core shape, often wood. This is done on smaller profiles such as window and door components.

FORMING PAN SHAPES: Fully annealed austenitic stainless steels are drawn with the same equipment and methods used on carbon steel, except that about twice as much power is required. Nearly twice as much reduction, however, can be obtained per stroke.

Rather than deep draws requiring several strokes, architecture makes use of shallow recessing, particularly in large area components such as spandrel panels.

Simple, multiple or compound shapes can be produced by one press stroke with a single set of dies. Matching tooled male and female dies are used for relatively intricate shapes. Less complicated shapes can be produced with one tooled die working against a flexible pad or opposed by a hydraulic force. Single die methods often are used to help make small runs economical.

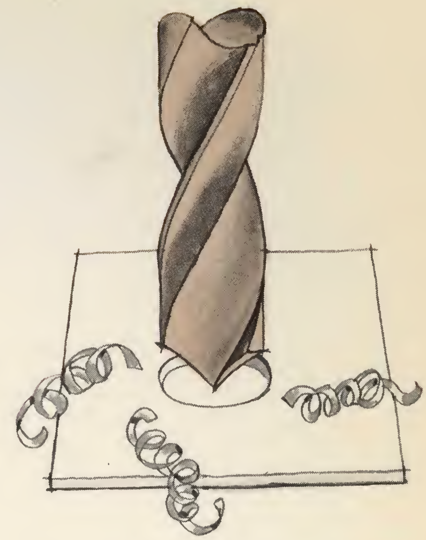


EXTRUSIONS: The French-developed Ugine-Sejournet process makes stainless steel extrusions practical, employing molten glass for lubrication and heat insulation. Die costs are comparable to those of other architectural metal extrusions and make production practical for small-quantity requirements. Existing equipment can produce a variety of solid and hollow shapes.

New equipment and techniques are being developed continually and the designer should consult the fabricator or producer concerning detailed possibilities. Currently, shapes are confined to a "maximum circumscribed circle" (diameter enclosing the entire cross section) of 6½″. Maximum length is about 60 feet, minimum cross section 0.28″ and minimum segment thickness 0.125″ or $\frac{1}{14}$ of segment height. There are also limitations of minimum corner radius and channel-depth ratio. After extrusion, dimensions can be refined and finish improved by cold drawing.

LOCALIZED HOT FORMING: Localized heating and bending in the field, a common practice with carbon steels, should be approached only with great care where the austenitic stainless steels are concerned. In most of these grades temperatures of 900°F to 1600°F can cause precipitation of carbides that can result in cracking or in reduction of corrosion resistance.

MACHINING



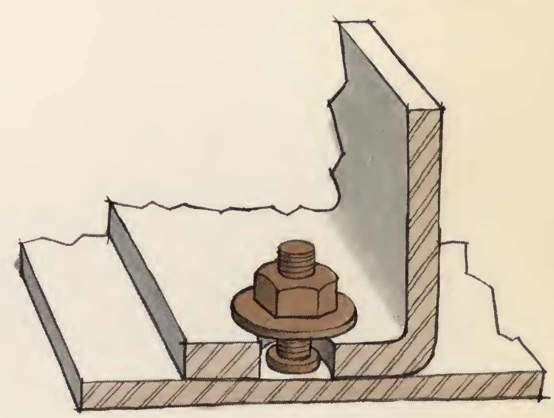
Tapping, threading, turning, milling, planing, broaching, and other common machining operations are fully practical with austenitic stainless steels, although such operations seldom apply to architectural specifications. Drilling, however, which is also a machining operation, often does apply.

DRILLING: Holes of virtually all sizes are drilled with sharp high-speed steel drills. Generally, short drills are used for extra rigidity in deep holes. Grooved or high-helical drills are sometimes preferred to provide easy chip clearance, since austenitic steels are more "stringy" than carbon steel. Cutting is slower than with carbon steel; a slow spindle speed is combined with constant steady cutting to avoid any riding of the drill on the metal which could result in surface work-hardening. Also to avoid work-hardening, an extra-light tap with a center punch is used, and the preferred punch has a triangular point. Especially with light gauges, a back-up block of soft steel or cast iron helps prevent burring. Cutting oil is applied to control temperature.

FASTENED JOINTS

If a joint is designed to be adjustable, to allow movement, to provide for simplified field assembly or to make parts removable without destruction, the following methods of joining apply:

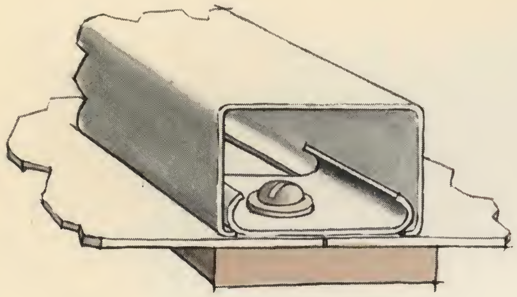
MECHANICAL FASTENERS: A full selection of austenitic stainless steel screws, bolts, clips and other fastening hardware is available and is used for fastening stainless to stainless and stainless to other metals and materials. Stainless fasteners are also preferable for fastening aluminum parts together. Carbon steel fasteners are not used where moisture or corrosive atmosphere is present.



WELDED STUDS: Welded studs are rapidly gaining acceptance for architectural stainless steel. Proprietary systems of special studs and stud welding guns make application fast and economical. Studs (often threaded or tapped) are welded to one part to provide means of mechanical fastening to another part. Two types of systems which are used are designated as the Arc Welding type and the Capacitor Discharge (CD) type, with largely separate applications.

Arc stud welding systems are used where design calls for parent metal thicknesses greater than 0.062″, and where backside marking is not a critical factor. Also, a wider variety of stud shapes are available in arc welding systems.

CD stud welding uses lower heat input and is especially useful for applying studs to the reverse side of light gauge sheet



stainless steel, with little or no effect on the finish of the other side. Reverse-side effects usually are unnoticeable on mat, textured or coated finishes.

LOCK SEAMING: Lock seams are made with the same equipment used on mild steel or galvanized iron. Seams can be sealed with solder or sealants.

SNAP-ON PARTS: Springback properties of cold rolled tempered austenitic steels are an advantage in the case of self-supporting snap-on building components. Such design requirements as wind resistance and ease of installation and removal are satisfied by a controlled degree of contour in the snap flanges. Both parts of the joint should be stainless steel, especially where exposed to moisture or corrosive atmosphere.

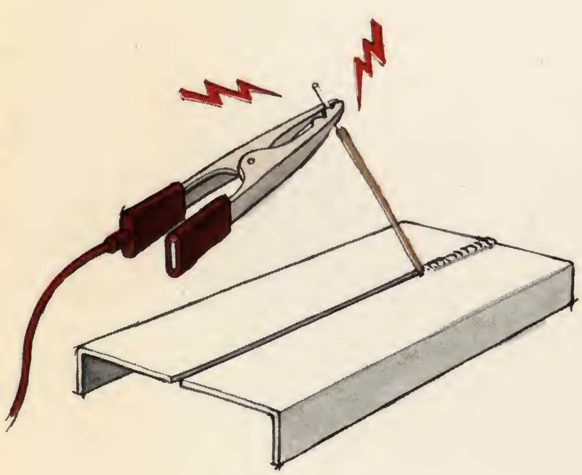
FIXED JOINTS

If a joint is designed to be permanent, rigid, secure against loosening, watertight or airtight, one or more of the following joining methods are used:

WELDING: For joints of maximum rigidity and permanence, all the common types of welding that apply to carbon steel apply equally to austenitic stainless steels. The most frequently used methods include arc welding with covered electrodes, submerged-arc, metal-inert gas, tungsten-inert gas and resistance welding. Where a strong preference of method exists, it will relate to such factors as gauge, size, configuration of parts to be welded and the number of assemblies to be produced.

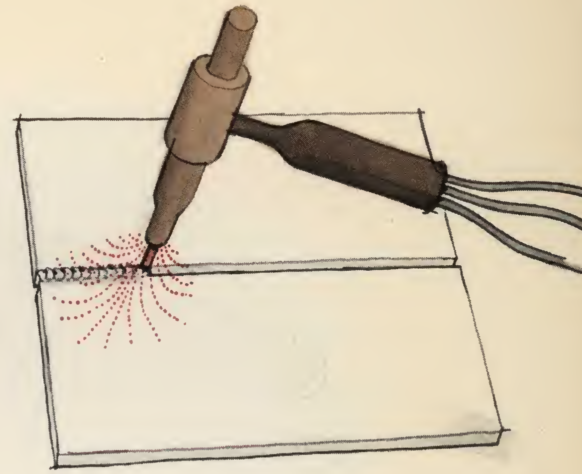
Compared to carbon steels, stainless steels have lower thermal conductivity and somewhat higher thermal expansion resulting in a greater tendency to distort during welding. Since less heat is used in resistance welding, stainless steels are especially well suited to this method.

In arc welding, stainless steel wire is used as filler, making it practical to blend joints with the parent metal. Difficulties of the kind encountered in blending aluminum welds do not exist. However, specifications tend more and more to discriminate between joints on which blending is required and those to be viewed only from a distance where grinding and blending are unnecessary.



The simplest and most frequently used method of arc welding is the COVERED ELECTRODE process. This manual process requires a minimum of equipment and is available in most fabricator shops. A length of filler wire coated with flux is used as an electrode in producing the arc and is consumed in the joint. As the wire flows in, the flux is consumed. Its primary functions are to stabilize the arc, to deoxidize the molten weld metal and to provide protection from the atmosphere during cooling.

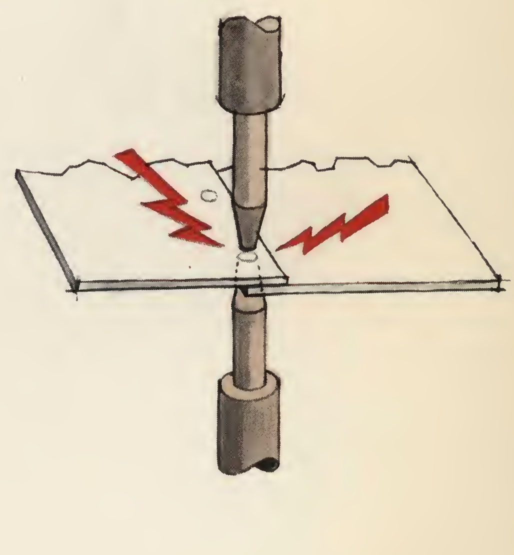
Covered electrode welding is unsuitable for welding stainless steel sheet thinner than 20 gauge. Furthermore, when welding heavier gauges, it is not as fast as some of the automatic welding processes, and it requires a high degree of skill to produce a sound deposit with uniform appearance. On the other hand, it requires only the basic welding equipment (power source and leads) and can be used to make field joints in any position.



A faster flux-employing method is the SUBMERGED ARC process. Adaptable to automation or semi-automation, it is accomplished with various types of equipment in which the arc is produced beneath a quantity of granulated or agglomerated flux. The electrode and usually the supply of flux are fed automatically, and either the work or welding nozzle may be moved by power or manually-operated equipment.

The METAL-INERT GAS METHOD (MIG), is a fast, effective process adaptable to semi- or fully automatic welding. The filler wire electrode is fed mechanically from a coil and is consumed. Shielding of the weld from contact with air is provided by a flow of argon or helium. Gas is preferable for this purpose because no slag is produced. For the light gauges of metal most often specified in architecture, "shorting-arc" type MIG welding applies.

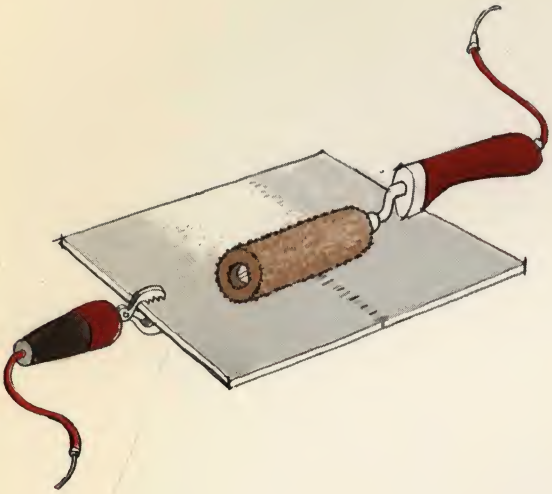
The TUNGSTEN-INERT GAS (TIG) method of arc welding also has the advantage of using gas as the shielding agent. In addition, the electrode in the torch is of tungsten and is not consumed. A filler wire may be needed for a given weld. The TIG method is slower than MIG welding, especially for heavy material. However, control is especially good and the method is highly applicable to materials in the range of 0.005″ to 0.12″ thick. Also, splatter is minimized and heat discoloration of the surrounding metal can be held to a light tint.



In RESISTANCE WELDING, the overlapping parts being joined are held between two electrodes which apply pressure. Heat is produced by an electrical current passing through the electrodes. No filler or flux is used. In spot welding, the most usual form of resistance welding, the electrodes remain in place until the joint has solidified, maintaining pressure and drawing off heat. Intermittent spot welding is fast and is especially economical for high production jobs. Of course, the resulting joint is not watertight and may not be as strong as a continuously welded joint. Watertight joints are formed by resistance seam welding, in which electrodes in the form of wheels make a series of overlapping spot welds.

WELDING TO CARBON STEEL: In the special case of welding to carbon steel, weld joints between the stainless and the carbon steel should be avoided in exposed positions, because stains may develop. In concealed positions the special

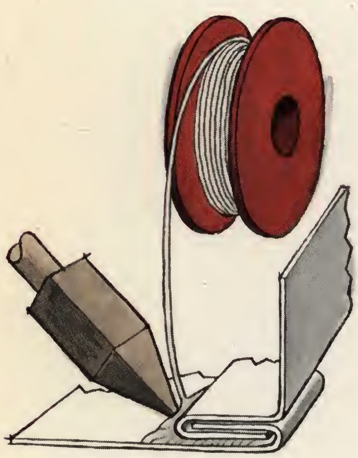
filler alloys are used. Pre-coating the carbon steel portion of the joint with one or more beads of the filler is beneficial in certain circumstances.



REMOVAL OF WELD DISCOLORATION is often necessary where the heat of welding discolors the surrounding area. Electro-chemical or mechanical methods are used in such cases to remove the thin layer of discolored metal. If adjacent surfaces cannot be disturbed, the electro-wand can be used. This is a rod connected to 8-24 volts A.C. Wetted with 50% phosphoric acid, it removes discoloring products only by electrolysis. No metal is removed. Discoloration may also be removed by grinding, buffing, blasting and pickling.

RIVETING: Riveting affects the strength and rigidity of stainless steel fixed joints relative to the number and size of rivets used. Rivets must be of stainless steel and stainless rivets up to ¼″ can be driven cold.

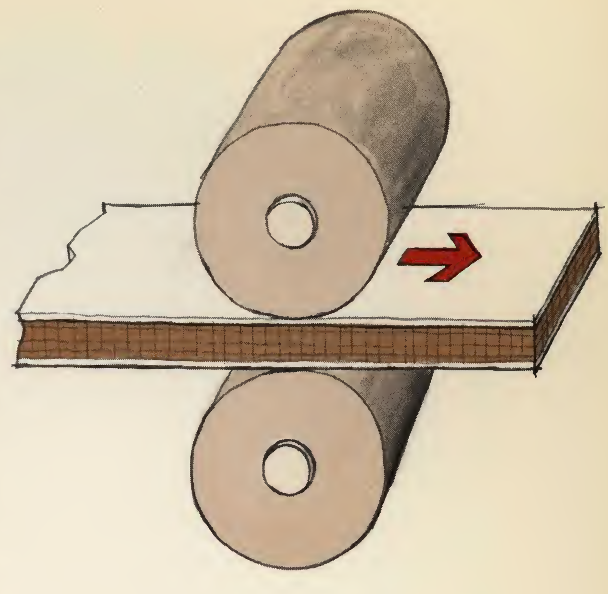
BRAZING: Brazing has found little application in architectural stainless steel fabrication. High-melting-point bronze rod brazing does not apply to stainless. Although silver brazing, often called silver soldering or hard soldering, is widely used in manufacturing, welding has been given almost complete preference by makers of large components such as those used in architecture.



SOLDERING: Solder is used to seal stainless steel joints, particularly in roofing applications. High-tin solder, preferable for color match and acid stainless steel fluxes are readily available. Thorough cleaning of the joint edges is important, and highly polished metal should be roughened with emery cloth. Pre-tinning is used where practical, especially to fill up lock seams, but often is omitted in the field. Soldering proceeds more slowly than with carbon steel because of slow heat conduction. After soldering, flux residue should be removed and the surfaces neutralized by scrubbing with ammonia or washing soda and then thoroughly rinsed with water.

STRUCTURAL ADHESIVES: The rapidly developing technology of structural adhesives seems to prohibit generalization. Various adhesives are being used successfully to join or laminate stainless steel to itself, to other metals, and to other materials. One important advantage is that adhesives cure either without applied heat or at relatively low temperatures; thus any problem of heat-developed stresses, impairment of mechanical properties or discoloration is avoided. In some instances, also, acceptable joints can be made faster with adhesives than with other available methods or can be made in the field, where other methods would be difficult.

On the other hand, enough variables in specific applications have been encountered to suggest caution. Designers should plan joints in terms of a selected adhesive, with the technical assistance of an experienced fabricator or the adhesive manufacturer. Besides the growing range of available adhesives, the forms of application also present an important selection to consider. These include liquids and pastes; dry film sheets or strips; and contact products.



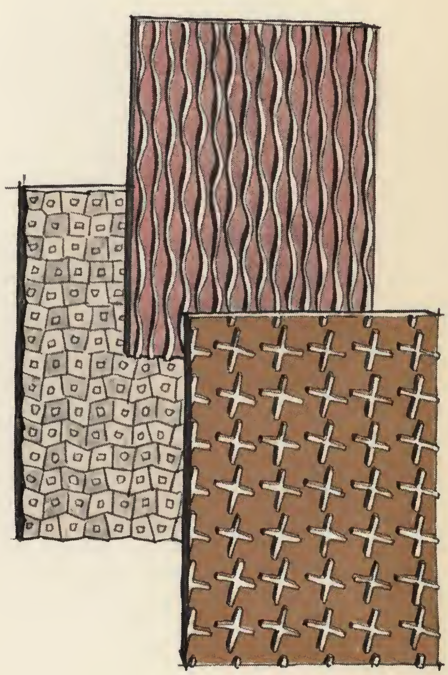
FINISHING

There is a considerable range of rolled or polished A.I.S.I. Industry Standard Mill Finishes, all of which are presented in the "Mill Products" section of this manual. Sheet and strip products in these finishes, particularly No. 2D, No. 2B, No. 3, and No. 4, are warehoused throughout the country. In addition, certain mills offer a selection of proprietary mill finishes of their own design. These finishes are polished or roll-produced for various scratched, patterned, or matte effects.

Also available is a group of proprietary special finishes provided by metal finishing specialists. These include patterns and color effects produced by texturing, etching, coating, and electropolishing.

TEXTURING is the term applied to a shallow embossed or over-all indented pattern pressed into sheet or strip products. On some products the textured pattern is also color coated. In rigidizing or texturing, the metal is rolled into a three dimensional pattern which strengthens the stock and provides interesting designs.

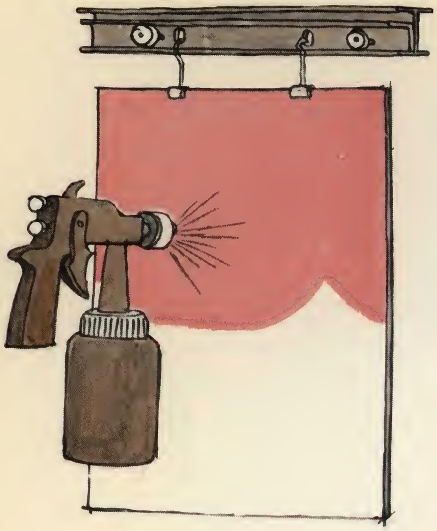
Textured and etched products also are used to meet the visual flatness requirements of broad panels and to reduce the visibility of minor scratches and dents.



ETCHING includes both acid and mechanical methods. Acid is used for an over-all matte finish or to remove metal around a pattern protected by a coating during the process.

BLASTING is mechanical etching using sand or glass beads to create various frosted or matte effects. Portable recirculating equipment is available so that glass blasting can repair or refinish stainless on site. Blasted rolls are used to produce a rolled matte finish which also can be duplicated on site.

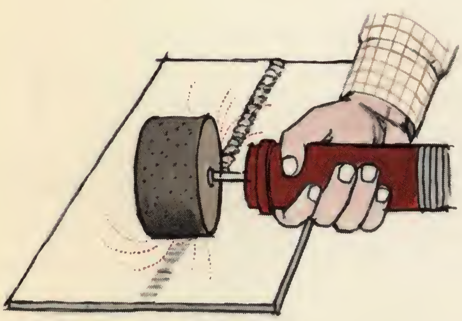
COATINGS may be organic or inorganic. Organic coatings in exterior or heavy traffic locations have introduced maintenance problems considered inappropriate to stainless steel. However, they are sometimes specified for the pliability when the user wishes to bend or form pre-coated stock, because economical requirements limit finishing after forming. Inorganic coatings



include porcelain (glass) and oxidizing, which are impervious to atmospheric conditions. Often a transparent paint or porcelain is used to permit the metal to appear through a tint. Oxidizing, a chemical effect involving the metal surface, is opaque black. Opaque coatings are rarely used except for creating patterns or contrasting strips. Coatings are not normally applied for protection since stainless steel itself is durable.

ELECTROPOLISHING, a simple electrolytic bath, produces the brightest available luster; the finish is imparted equally over the piece, including the inside areas of hollows and tight contours.

BLENDING AND REFINISHING: Stainless steel fabricators provide *refinishing* for a uniformly attractive appearance after fabrication steps that disturb the original finish. Grinding, polishing and buffing—progressively finer abrasive steps—are used to efface burrs, weld beads and scratches and to bring the surface to the desired appearance. The term *blending* applies when the fabricator works on limited areas to eliminate any visible difference between them and the original over-all finish. Since welding filler is selected to match the stainless steel being joined, the fabricator can make welded joints visually indistinguishable.



Fabricators offer their own finish to avoid blending to a standard finish. The number designations of several fabricator finishes follow those of the A.I.S.I. standard mill finishes, but the finishes themselves do not necessarily match. Thus, it is well for the designer to request samples from the fabricator before specifying.

To minimize and simplify refinishing, several factors should be considered: selection of original stock, fabricating alternatives, end use and shop protective measures.

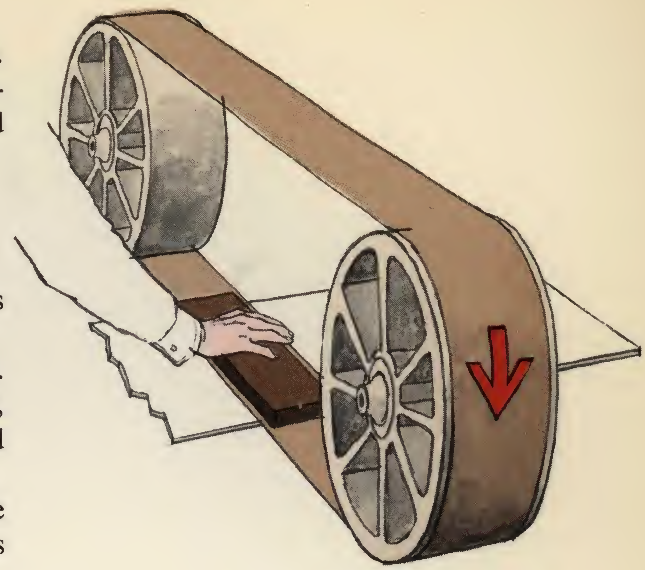
Only polished or scratch-rolled products can be abrasively blended. This eliminates No. 2D, and No. 2B, which are smooth-rolled. A number of *mill proprietary finishes* are specifically designed for easy blending. In some instances, the supplier provides special cloths or wheels that quickly reproduce the original finish.

Selecting a textured or etched stock may eliminate the need of blending after certain fabrication steps that produce small nicks or scratches.

In discussing the individual steps of fabrication, this manual refers to the refinishing requirements relative to various methods. The greater over-all advantage sometimes may dictate processes producing larger burrs or more heat discoloration than others, but general preference is given to minimizing these effects. At the same time, there is a trend to common sense judgment on whether or not refinishing is necessary at all. Before specifying, designers consider the range at which the part

will be viewed. Amount and direction of light also is important.

The *Metal Finishes Manual,* published by the National Association of Architectural Metal Manufacturers, offers detailed data useful to specification writers.



SHOP PROTECTION

In work, storage and shipping every practical precaution is taken to prevent damage to finish and edges.

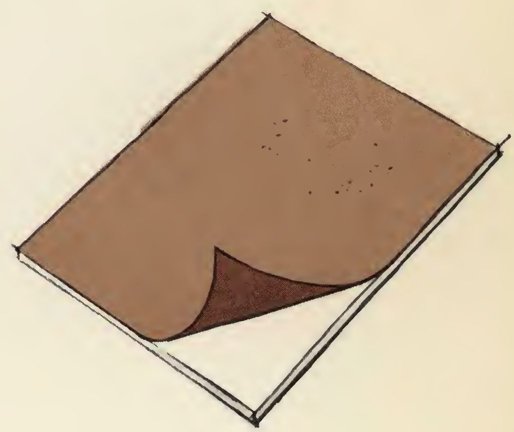
Shop cleanliness is especially important with stainless steel. There should be a minimum of dust, particularly metallic dust, in the work and storage areas. Carbon steel grinding is avoided in stainless steel shop areas.

Tools not used exclusively for stainless steel should be scrubbed before they are applied to stainless to prevent particles from lodging or imbedding in the surface of the stainless steel. Such imbedded particles, unless removed by subsequent chemical or mechanical treatment, may cause corrosion. For the same reason, carbon grits and grinding wheels are avoided and stainless steel wools are used. Sharp cutting tools and smooth forming dies are used to prevent nicks and scratches.

Prefinished sheets are usually covered at the mill, service center or shop with paper, tape or either sprayed-on or sheet plastic film (some transparent) for protection throughout fabrication and erection. Such coverings have specific limitations and service lives and following the manufacturers' recommendations eliminates removal problems.

Paper pads or temporary strips of tape are used between the work and sharp table edges, hold-downs, etc.

Interleaving paper normally is used in storage and in shipping sheet stainless steel (unless it is taped or coated). Storage in a dry place is important, since the paper can pick up and retain moisture. Sheets are shipped in strong-edged cartons or crates or wrapped and banded on pallets.

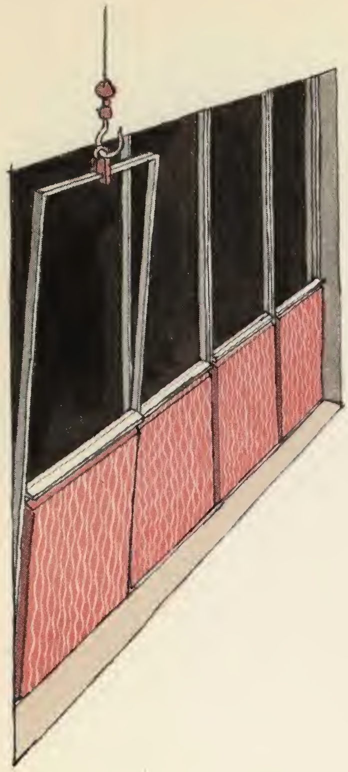


Stainless steel is protected by a natural clear oxide coating that forms on its surface. If carbon steel contamination occurs during fabrication or any other invasion of the natural protective coat causes staining, the entire piece should be immersed or swabbed with an acid cleaning solution.

INSTALLATION

Since appearance normally is important in stainless steel applications, the designer often specifies installation handling and scheduling details that otherwise might be left to the discretion of the general contractor.

Installation of ground floor exterior and all interior stainless steel is scheduled, if practical, after other trades have completed any work that could produce accidental scratches, dents



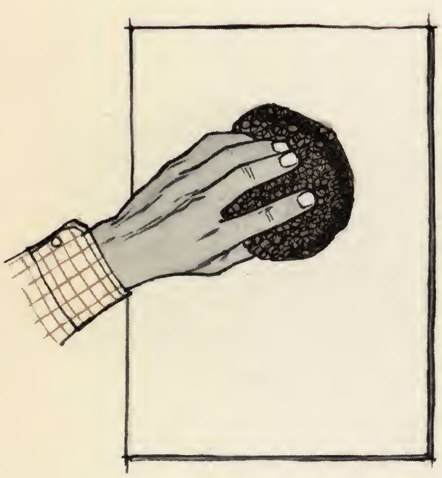
or stains. Until that time stainless steel components should remain indoors, wrapped and in their shipping containers.

Early installation can be scheduled for exterior applications above the level where construction traffic is heavy.

If early installation is necessary, and the material may be subject to abuse or contamination, appropriate protection is required. When a protective tape or film covering is used over the stainless steel surfaces, the manufacturer's recommendations are to be followed closely regarding exposure and removal. Tape must not be permitted to harden or set.

If muriatic acid or other corrosive cleaning preparations are to be used on adjacent masonry, installation of stainless steel is scheduled after this step. If it is impractical, the stainless steel components must be flushed with water immediately after being exposed to the masonry cleaning process.

CLEANING



Thorough inspection and cleaning of the stainless steel is scheduled as one of the final construction steps. This is not only to insure the initial appearance of the job, but it will eliminate any corrosive residues and reveal any needed repairs.

Common mild detergents and warm water are usually sufficient for this step. The detergent should be thoroughly rinsed off. A final dry wipe eliminates water deposits.

After any protective paper, tape or film has been removed, a residue may be left. This may not be immediately visible, but if it remains it will act as a dirt trap. A solvent or special cleaner recommended by the manufacturer usually is needed to remove any adhesive residue.

If dust and grit is present on stainless, it should be flushed away as the first step in final cleaning. Special environmental deposits may call for special cleaning materials, as may greasy smudges, spills, construction materials and fingerprints.

Carbon steel wool must never be used. Stainless steel wool is available and ideal. All coarse abrasive cleaners should be avoided. Use of a light abrasive powder may prove necessary, but any such product should be used with care and applied in the same direction as the grain or finish lines. Corrosive cleansers should be avoided if possible, especially those containing chlorides. If such a cleanser is required to remove a particular type of dirt, it must be followed by a thorough rinsing and drying.

For detailed cleaning information refer to Data Sheet No. 1, entitled "Stainless Steel for Maintenance Economy," in "Book 2" of the *Architects Stainless Steel Library.* Copies are available from the Committee of Stainless Steel Producers, American Iron and Steel Institute, 633 Third Avenue, New York 17, N.Y.

DESIGN AND DETAIL

GUIDELINES FOR DESIGN

This section, "Design and Detail" concludes Part I of Volume 4 of the Stainless Steel Library. Part II "Detailing" will be forwarded for inclusion in the book upon its completion.

The characteristics of stainless steels which have made them acceptable from aesthetic and maintenance points of view are, generally, well understood. There are, however, considerations for design based upon mechanical and physical properties. For example, the high tensile strength and high modulus of elasticity and ductility of stainless steel must be weighed to assure its proper use as a structural material. Its thermal characteristics such as a low coefficient of expansion and low thermal conductivity provide significant design advantages. Stainless is also chemically compatible with most materials commonly used in building construction.

In this section, the known performance characteristics of stainless steel, and the experience derived from previous design are brought together to provide guidelines to facilitate the task of the designer.

STRENGTH AND RIGIDITY

For most architectural metal applications, the designer is concerned with the unit stress in bending and the modulus of elasticity of the material. Strength and stiffness are basic factors in determining the size and shape of a component. The architectural metal components may be strong enough to carry the loads imposed upon them, yet lack the stiffness needed to prevent excessive bending when the loads are applied. An excessive deflection may cause damage to brittle adjoining materials such as glass or plaster. Hence, the modulus of elasticity is often the governing design criteria.

Stainless steels, even in their softest or annealed condition, possess high yield strength. The designer may, therefore, generally assume that if the deflection requirement has been satisfied in his calculations, stainless steel will provide ample strength in the component. By taking advantage of this exceptional rigidity, several benefits will be attained; the relatively high cost per pound of stainless steel will be partially or wholly offset by using less material, unusual and slender forms can be achieved and shop assembled units can be larger as a result of the lower weight per unit material.

FLEXIBILITY

Stainless steel has a high fatigue limit (the highest unit stress at which the material can be subjected to a very large number of reversals of loading without showing signs of failure). In other words, stainless possesses a definite flexibility which can

be utilized in detail design. For example, "bellows members" can often replace slip joints and their attendant problems of sealants to accommodate for thermal movement. Essentially, the bellows member is a U-shaped element, frequently a mullion that flexes open and closed to allow movement in adjacent members.

THERMAL CHARACTERISTICS

The stainless steels have a relatively low coefficient of expansion. The dimensional stability resulting from this creates the design advantage of reducing the necessary number of expansion joints and diminishing movement within them.

A further design feature is available as a result of the low thermal conductivity of stainless steel. Exposed door and window components result in lower heat gains in summer and losses in winter.

STRENGTH AT ELEVATED TEMPERATURE

In certain code requirement situations, where fire safety is of critical importance, the designer should be aware of the high strength of stainless at elevated temperatures and take advantage of the ability of stainless to maintain structural integrity at temperatures where other architectural metals fail.

FLATNESS

With all architectural sheet materials, the matter of assuring flatness is of importance to the designer. The use of stainless steel, however, tends to accentuate the problem, particularly since the use of this quality material demands exacting standards of appearance. A number of factors, occurring singly or in combination, can result in surface distortion. Among these, the designer should be aware of unequal stresses resulting from fabrication, erection or building movement, and potential thermal variations.

While absolute control of these factors is seldom possible at the design phase, precautions can be taken to minimize the problem. As an example, the use of large, flat, unstiffened surfaces in combination with highly reflective finishes should be avoided. In such areas, textured or patterned surfaces will provide optimum flatness. Because there is such a wide variety of textures and patterns available, the designer should obtain the producer's recommendations on dimensional limitations to ensure visual flatness. The designer may wish to create his own distinctive panel pattern or profile which can be press formed so as to combine aesthetic appeal with practical stiffening

effect. Heavier gauges and pronounced patterns permit the use of large unsupported areas such as spandrel panels, decorative screens, and curtain wall without visible distortion.

Stainless can be successfully bonded to several flat and rigid materials to achieve visual flatness. Cement asbestos board, most wood product hard·boards and plywood have proven satisfactory for lamination. Laminating should not be specified without consultation with stainless producers and other experts.

Discontinuous support for stainless sheet can be imparted by a wide range of stiffening member approaches. In general, the spacing of these members bears a direct relationship to the thickness of the material. However, textured and dull finishes require fewer support members per unit area than highly polished finishes.

An excellent detailed reference to the problem of flatness is available in "Curtain Walls of Stainless Steel," School of Architecture, Princeton University, 1955, Chapter 5, pp. 99-134.

CORROSION RESISTANCE AND COMPATIBILITY WITH OTHER MATERIALS

Use With Concrete and Masonry—Combining stainless steel and concrete in pre-cast building components offers the designer many new forms of expression for exterior walls and other building features.

Stainless steel is unaffected by the alkalines normally present in concrete and mortar. Consequently, stainless may be imbedded in such construction materials or used as an exterior form without the use of protective coatings.

Precautions:

1. Some frost inhibitors, used when pouring concrete in freezing weather, contain chlorides which can attack stainless steels. Specifications for concrete work should cover the necessary precautions in this regard, i.e., by excluding the use of frost inhibitors containing chloride.
2. The use of muriatic or builders acid on adjacent masonry or brick work should be accompanied by care and caution and any splashing of this corrosive acid should be washed off the stainless steel immediately.
3. Drainage from slag aggregate roofs should be carried away from stainless steel fascia and other exposed wall components.

Use with Other Metals—Stainless steel complements and is generally compatible with all traditional building metals. Stainless reflects the colors of its environment either in daylight or with floodlighting. While it can be effectively combined with

bronze and other metals in entrance lobbies and elevator cabs. It is unwise to combine bronze and stainless for outdoor applications unless the two are insulated from each other or are so positioned that the copper oxides from the bronze do not drain onto the stainless steel and leave their stain.

The designer should avoid the use of mild or carbon steel (even though painted) in close proximity with stainless on exterior applications, particularly where the mild steel is exposed to the elements, since the rust developed by the carbon steel may impair the stainless and adversely affect its appearance. Aluminum and stainless steel are usually compatible. Some outdoor combinations of aluminum and stainless, however, can result in galvanic corrosion of the aluminum with unsatisfactory effects.

EASE OF FABRICATION

Stainless steel is highly ductile in the plastic range especially in the annealed condition. Annealed austenitic stainless sheets, 18 gauge or thinner, can be bent 180 degrees and flattened without cracking. Thus, it is highly suitable for brake forming or roll forming, providing a range of shapes for framing and similar functions otherwise served by heavier extrusions of other metals.

Increased use of roll forming, a high production method, has led to the availability of numerous economical standard framing sections. The selection of standard fabricated architectural components and products is being increased rapidly through various mass production techniques. In the interests of economy, designers may find it worthwhile to incorporate such products.

Generally, simplicity of shape in forming operations yields economy, especially where small quantities of custom work are factors. However, in press brake bending and shallow pan-shape drawing or stamping, multiple and compound bends and impressions are now being made with minimum tooling and fabrication costs.

Generally simplicity of shape in forming operations yields economy, especially where small quantities of custom work are a factor. However, in press brake bending and shallow pan-shape drawing or stamping, multiple and compound bends and impressions are now being made with minimum tooling and fabrication costs. These developments have enlarged the freedom of stainless steel design in very recent years.

Welding stainless steel joints in hidden locations and stud welding of mechanical fasteners to the back of stainless sheet are fast, simple operations and create little if any refinishing requirement. The designer may specify welded joints wherever the strength, rigidity and permanence of welding are appropriate.

Mechanical fasteners made of stainless steel are available in great variety and are preferred for strength, permanence, cor-

sion resistance and compatibility. Also, the elasticity of stainless makes it practical to design snap-in strips and panels that are largely or wholly self-fastening.

SUMMARY

Stainless steel presents unusual and rewarding opportunities to the designer willing to make a careful and analytical approach to his problem. Its limitations will seldom preclude its use and a thorough understanding of its nature will serve to eliminate in advance the prospect of mistakes. The following recommendations and precautions are offered to further guide the designer.

Recommendations:

1. Investigate the wide range of stainless steel products.
2. Take advantage of the high strength and high modulus of elasticity of stainless steel load bearing members.
3. Utilize the flexibility of stainless.
4. Utilize the impact and abrasion resistance of stainless steel in areas of maximum traffic.
5. Design anchors and fasteners of stainless steel to take advantage of its compatibility with concrete, masonry and other architectural materials.
6. Be aware of the various stainless steel alloys and select the type most suitable for the particular application.
7. Obtain technical assistance from the stainless steel industry.

Precautions:

1. Avoid the use of polished or bright finishes for large areas, where visual flatness is desirable.
2. Design for drainage features on outdoor applications. Avoid pockets and crevices which might accumulate pollution.
3. Avoid unnecessary finishing operations.
4. Avoid direct contact with carbon steel and copper alloys in areas where moisture can accumulate.

TECHNICAL ASSISTANCE

For sources of further assistance contact your nearest INCO district office listed in the back of this manual. Architectural specialists at The International Nickel Company and most stainless steel producers and qualified fabricators are available to consider stainless steel problems without obligation.

Additional data on the design and comparative properties of stainless steel and other metals are listed in the Metal Curtain Wall Manual of the National Association of Architectural Metal Manufacturers.

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No. 5 Window Frames
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No. 8 Flashings (1964)
No. 9 Expansion Joints (1964)
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Stainless Steel Sliding Doors and Frames
Stainless Steel Windows
Stainless Steel Curtain Walls or
Stainless Steel Components in Curtain Walls
Stainless Steel Roofing Flashing and Accessories

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